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# GUIDE FOR THE USE OF INTERGRAPH RANDMICA STRUCTURAL SOFTWARE FOR COMPUTER-AIDED DESIGN AND DRAFTING (CADD)

by

CADD Center

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This Guide describes procedures to be used by all US Army Corps of Engineers structural engineers using the structural analysis software Intergraph RandMicas. Following the procedures outlined in this guide should simplify the process of model generation, load application, and structural analysis. The Guide establishes procedures for using the software by giving detailed modeling steps for four typical structural models. Suggestions and recommendations are given that should reduce repetition of work and eliminate avoidable errors.


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## PREFACE

This Guide describes procedures to be used by all US Army Corps of Engineers personnel using the structural analysis software RandMicas. Following the procedures in this guide should simplify the process of model generation, load application, and structural analysis.

The Guide establishes procedures for using the software by giving detailed steps for four typical structural models. Suggestions and recommendations are given that should reduce repetition of work and eliminate avoidable errors.

The following references were of great assistance in preparation of the Guide:

> Intergraph-RandMicas (IRM) Analysis Grahics Interface (Structural), November 1, 1988. Intergraph Corporation, Huntsville, AL
>
> Intergraph-RandMicas (IRM) Analysis User's Guide with Alphanumeric Interface, November 1, 1988, Intergraph Corporation, Huntsville, AL

Permission to use the copyrighted material was received from Intergraph Corporation.

The Computer-Aided Design and Drafting Center (CADD-C) convened a group of structural engineers to create the examples in this guide. Members of the group included Mr. Dean Spenser, Savannah District, Mr. Paul Blackburn, Tulsa District, Mr. Elias Arredondo, Sacramento District, and Mr. Robert Grause, Intergraph Corporation. The Guide was compiled by Mr. Steven Hatton, structural engineer, CADD Center, Information Technology Laboratory. The time consuming efforts of all participants in the preparation of this Guide are gratefully acknowledged. The work was performed under the direction of Dr. N. Rahdakrishan, Chief, Information Technology Laboratory (ITL), Dr. Edward Middlteton and Mr. Carl S. Stephens, Chiefs of the Computer-Aided Engineering Division and the CADD-C respectively. The Commander and Director and Technical Director of WES during the preparation of this Guide were COL Larry B. Fulton and Mr. Robert W. Whalin, respectively.

## TABLE OF CONTENTS

# 1. Introduction

## 1.1 Purpose and Scope

The purpose of this report is to present step by step procedures for the solution of some common structural models using Intergraph's RandMicas. It is an attempt to familiarize new users with the operation of IRM by providing hands on experience with checkable results. No attempt is made to reproduce the User's Guide for RandMicas. It is assumed that the user is familiar with the fundamentals of IGDS, and has some exposure to SMS, and IRM. Reference is made to the Intergraph manuals for these products for specific instructions.

## 1.2 Origin of Guide

Groundwork for this report began in a meeting at the Sacremento District in April 1989. At this meeting, the "SWAT" team, Messrs. Dean Spenser, Savannah District; Paul Blackburn, Tulsa District; Robert Grause, Intergraph Corporation; and Elias Arredondo, Sacremento District; created example problems 1-4 respectively. They each prepared an outline of the procedure required to generate and analyze their specific problem. The CADD Center assimilated these outlines into a common format and produced this guide.

## 1.3 Creation of the Model

a. When modeling a complex geometric structure with IRM Version 8.8.2, it is recommended that the user begin the process in the Structural Modeling System (SMS), formerly CSM. SMS facilitates the modeling of structures by allowing the user to select members directly from the AISC or user defined tables. The user will not be required to input mechanical and physical properties for the members since they are automatically stored. Version 8.8.3 of IRM provides a similar modeling approach and reduces the need for this interim step. However, the drawing extraction feature of SMS may still make it a desirable place to begin modeling.

b. If a structure has been created through SMS, it can be written to the Common Structural Database (CSD) and accessed by IRM through the use of a .BLU, or "blue" file. Loads and node constraints are then placed in IRM and the structure is ready for analysis.

c. Appendix A contains guidance for accessing IRM and creating a typical project. The example given is for a 3D model using the Intergraph default database as a seed file. Other model types or customized seed files may be used in a similar way.

## 1.4 Coordinate System, Sign Convention, and Units

IRM uses a global coordinate system which is based upon a right-handed Cartesian coordinate system. All angles, rotations, and moments are based upon the right-hand rule. Output is given in the global system except for line elements and shell elements which are output in their local systems. Translations and forces are positive when acting in the positive direction of their axes. Units of output are consistent with those selected in the model database and those input into the load vector.

## 1.5 Generation of Output

a. The format for output for an IRM run must be setup prior to analyzing the model. The Analysis Setup Menu provides a great deal of flexibility to the user for determining what the output will contain and how the analysis should be performed. The analysis setup may be done in the alphanumeric environment or from the screen menu in the Graphics Interface.

b. Repetitive entering of the Analysis Setup may be avoided by utilizing a customized seed file when creating a project file. Commonly used options for the Analysis Setup include:

1. Turn on the Automatic Node Stabilization from "Processing Options-General Processing Options".
2. Select static analysis from "Processing - Solution Modes".
3. From "Results Options - Static and Response Spectrum", turn on Load Case Results, Load Combination Results, Node Displacements, and Line Element End Actions.
4. From "Report Selection-Model Definition", turn on Analysis Options and Model Summary, Units, Load Case/Load Combination Data, Line Element Data, and Line Element Loads.
5. From "Report Selection-Results", turn on Solution Statistics and Unstable Node Report, as well as desired reactions, displacements, and end actions.

c. Output generated upon completion of an IRM analysis will generate three print files of the format (Your Project Name)00i.PTR. File 001 will contain project units, load case and combination data, material properties, node coordinates, and element properties. File 002 will be the node stabilization report. File 003 contains the specified output including the process warning report, displacements, reactions, and member forces. The 00i number of the files will increase each time the model is analyzed unless previous files have been deleted. These files may be output to a printer or viewed on screen with a text editor.

## 2. Specific Example Problem Instructions

### 2.1 Cantilevered Beam

a. Description: This is a simple demonstration problem consisting of one 10 foot long cantilevered steel beam, fixed at the left end, with a concentrated load of 1 kip located at the right end and directed downwards. The self-weight of the beam will also be included in this analysis. See Appendix B for typical results output and a model sketch.

b. Solution Approach: No special seed file is used for this problem, therefore, all parameters not adequately set by the product default seed file will be set in this example.

c. Input Problem Data:

(1) Begin model by setting display characteristics:

-Select ACTIVE PARAMS.
-Select MODELING PARAMETERS - LABELS.
-Toggle to LABEL FOR Nodes.
-Set levels, colors, etc. as desired. Recommend size be 30 dits for 1/8" scale plotting.
-SAVE and repeat for Elements, then SAVE and RETURN.
-Select LOADING PARAMETERS - NODAL LOADS.
-Select NODAL LOAD VECTORS.
-Set display attributes of loads. Recommend:
L1=2, L2=4, F1=1, and F2=5.
-SAVE and Exit all tutorials.

(2) Set material types and element properties:

-Select MATERIAL.
-Select ISOTROPIC and set material values. For this example use an A36 steel beam.
-Set Density Flag to Weight.
-Return OK and BYE
-Select ELEMENT PROPS - BEAM ELEMENT STANDARD SECTION PROPERTIES.
-Keyin W8X24 for Section Name.
-Return OK and BYE.
-Select PLACEMENT DATA PARAMS.
-Toggle Design Type to BEAM.
-Select Material as A36 and keyin W8X24 for element property.
-Set the Cardinal Point at 8 (Top of steel).
-Set no member end releases.
-Toggle all prompt boxes to no.
-Exit tutorial.

(3) Place member directly without first placing IGDS element:

-Keyin VI=Front and select a view.
-Select PLACE - MEMBER - BEAM and give a dp for the left end of the beam in the front view.
-Keyin DX=10,0,0.
-Reset twice.
-Select LABEL and COMPONENT NODE.
-Place dp in the front view for UID.
-Select GROUP ALL, Reset to backup, and place dp for permanent labels.
-Select COMPONENT MEMBER.
-Repeat labeling procedure for members.
-Reset to Exit.

(4) Generate loads and place onto the beam:

-Select GENERAL LOADS - CASE/COMB.
-Select LOAD CASE and keyin: LC1, static analysis Dead load, Active, etc.
-SAVE
-Keyin: LC2, static analysis, Dead load, Active, etc.
-Save and select LOAD COMB.
-Set Load Combination Name to: COMB1.
-Set Load Combination to: LC1+0.75*LC2
-Set the Global Multiplier to: 1.0
-Save and Exit tutorials.
-Select PLACE - LOAD - NODE CONCENTRATED.
-Keyin: LC2, 0 (for Force), RESET (to reorient vector), (0,0,-1), 1 (magnitude).
-Snap to Node 2 and dp to accept.
-Reset 3 times and Exit tutorial.

(5) Set Boundary Conditions (Supports):

-Select BC's command and CONSTRAINTS.
-Toggle fixity to: T1 T2 T3 / R1 R2 R3
-dp to accept.
-Select node 1 for single component and accept.
-Reset twice and Exit tutorial.

(6) Setup Analysis:

-Select ANALYSIS SETUP.
-Select PROCESSING - SOLUTION MODES.
-Select STATIC ANALYSIS.
-Select RESULTS OPTIONS - STATIC & RESPONSE SPECTRUM.
-Toggle on items: 4, 5, 6, 9, & 10.
-Select REPORT SELECTION - MODEL DEFIN.
-Toggle on items: 2, 3, 6, 12, 16, & 18.
-Select REPORT SELECTION - RESULTS.

-Toggle on items: 7, 8, & 16.
-Exit tutorial.
-File Design.
-Stop IRM and exit design file.

d. Execute Analysis:

(1) Self-weight loads must be applied in the alphanumeric environment. To set self weight loads, after exiting the design file:

-Select option #6 to Terminate.
-Select option #2, Alphanumeric Interface.
-Select option #1, Analysis.
-Select option #7, Load Entry.
-Select option #3, Line Element Load Entry.
-Keyin LC1 for Load Case Number.
-Keyin 1 for Line Element.
-On one line at the LOAD prompt keyin:
BODY Z -.49
-Keyin END at the Line Element prompt.
-Exit to the ANALYZE JOB Option #9 and select.
-Choose between Interactive or Batch.
-Exit IRM.

2.2 2D Rigid Frame

a. Description: This example is a three member moment resisting frame, comprised of two twenty-foot columns pinned at the base, and a twenty-foot beam connecting them at the top. The beam is loaded full length with a 1 kip/ft uniform dead load. One column is loaded at the top with a 2 kip concentrated lateral live load. See Appendix C for typical results output and a model sketch.

b. Solution Approach: IRM was used to create the model for this example. A customized seed file was used to create the project. The seed file presets all parameters required for this analysis which are not specifically set in this example.

c. Input Problem Data:

(1) The structure was drawn graphically using IGDS commands. The sequence of commands is as follows:

-Type LV=1 to place structure on level one.
-Type VI=FRONT and select a view by placing a data point(dp) in that view.
-Select the PLACE LINE command.
-Place a dp for the bottom of the left column.
-Type DX=0,20,0
-Type DX=20,0,0

-Type DX=0,-20,0
-Reset

(2) Set material properties and element type through the following commands:

-Select the MATERIAL command.
-Select ISOTROPIC from the tutorial.
-Verify that the material listed is A36 steel.
-Change or "RETURN OK" and BYE.
-Select the ELEMENT PROPS command.
-Select BEAM ELEMENT STANDARD SECTION PROPERTIES.
-Verify that the AISC table is listed as current.
-Keyin W18X35 for Section Name.
-Return OK and Bye.

(3) Define the load parameters to set levels, colors, and relative magnitudes of load cases with the following:

-Select the ACTIVE PARAMS command.
-Select LOADING PARAMETERS - ELEMENT LOADS.
-Select LINE ELEMENT LOAD PARAMS - L.E. DISTRIBUTED.
-Set the appropriate boxes to:
    L1=1.75 L2=3.75 F1=1 F2=5
-SAVE and Return
-Select LINE ELEMENT LOAD PARAMS - L.E. CONCENTRATED
-Set the appropriate boxes to:
    L1=2 L2=4 F1=1 F2=5
-Save and Exit the tutorial completely.

(4) To set the member placement parameters the following steps should be used:

-Select PLACEMENT DATA PARAMS
-Toggle design type field to BEAM
    Material Property = A36
    Element Property = W18X35
    No member end releases
    Cardinal Point(CP) = 15 (shear center)
    Angle = 0
-Toggle element type field to COLUMN
-Repeat the beam parameters but place a dp in the element property prompt box. This will cause you to be prompted for the section when placing the columns.
-Exit

(5) Set up the load cases and load case combinations in the following manner:

-Select the GENERAL LOADS - CASE/COMB command.
-Choose LOAD CASE from the tutorial

| | | |
|---|---|---|
| Load Case Name: | LC1 | LC2 |
| Analysis Type : | Static | |
| Load Type : | Dead | Live |
| Active : | Yes | Yes |
| Convert Nodes : | No | No |
| Level : | 20 | 21 |
| Color : | 2 | 4 |
| | SAVE | SAVE |

-Choose LOAD COMB

| | |
|---|---|
| Load Case Combination Name: | COMB1 |
| Load Combination : | LC1+LC2 |
| Multiplier : | 1 |

-SAVE and Exit Tutorial

(6) Place the beam and columns through the following commands:

-Select PLACE MEMBER with active design type COLUMN.
-Place a dp at the bottom of the left column and then another at the top.
-Type in W10X22 for the element property.
-Reset to the "start of member" prompt.
-Place a dp at the top of the right column and then another at the bottom.
-Keyin W12x53.
-Reset to start of member prompt.
-Select active design type BEAM.
-Place a dp at the start and end of the beam.
-Reset out of the command.

(7) Establish Boundary Conditions with the following:

-Select the BC's command and CONSTRAINT (The first box of the tutorial that appears.)
-Hit dp or resets to modify the constraints until they appear as: T1 T2 T3 / R1 R3
-Select Group Fence and place a fence around both column bases.
-Accept group of two column bases.
-Reset twice and exit the tutorial.

(8) Apply the loads to the structure as follows:

-Select PLACE and the component LOAD.
-Select the uniformly distributed load symbol.
-Answer the prompts: LC1, Global Direct, Z, -1
-Select SINGLE as the group and place a dp on the beam.
-dp to accept then reset three times to Exit.
-Select the NODE LOAD - CONCENTRATED
-Answer the prompts: LC2, Force, Reset (to reorient the load vector), (1,0,0), 2

-Place a dp at the upper node on the left column and another to accept the node.
-Reset three times and exit the tutorial.
-File Design.

d. Execute Analysis: If the Analysis Setup was not set in the seed file it will have to be set at this point. In this example, the output format was specified in the seed file. The structure may now be analyzed by selecting the ANALYZE command at the top of the AEC Menu.

2.3 2D Hanger Truss

a. Description: The problem involves a 2D model of an aircraft hanger truss. The truss is comprised of wide flanges and WT sections. Concentrated loads are applied at various top and bottom chord panel points in five separate load cases. See Appendix D for typical results output and a model sketch.

b. Solution Approach: This problem was analyzed by inputting members directly into the IRM model without using SMS or IGDS graphics. The main objective of this example is to show how a 2D model can be analyzed in a 3D Thin Shell model. This will be desirable in many cases primarily because the vertical axis may be set to Z, allowing direct translations to and from SMS. By using the "Active/Inactive" capability of IRM, this method can also be used to analyze and design 2D portions of a full 3D model. Almost all Active, Element, Material, and Analysis Setup parameters can be set in the seed file and are done so in this example. Procedures for presetting these parameters is as described in the preceding examples.

c. Input Problem Data:

(1) Set physical member parameters:

-Select PLACEMENT DATA PARAMS.
-Set design type to COLUMN.
-Set element property to W12X50.
-Set Orientation to VECTOR (1, 0, 0).
-Set Cardinal Point prompt box to On.
-Set design type to BEAM.
-Set element property to WT7X49.5.
-Set Orientation to VECTOR (0, 0, 1).
-Set member end releases to:
Start: RY RZ End: RY RZ
-Turn on prompt boxes for Rotate Section Properties and Cardinal Point.
-Set design type to BRACE.
-Keyin WT4X9 as section name, Card. Point = 15.
-Set Orientation to VECTOR (0, 0, 1).
-Turn on prompt for Rotate Section Properties

and Orientation.
-Exit the tutorial.

(2) Set AEC locks:

-Select LOCKS command.
-Verify AEC locks set to: At Connection, On Split New Member, Unloaded Interior, Yes, Yes
-Exit the tutorial.

(3) Place physical members:

-Select PLACE MEMBER COLUMN.
-Keyin XY=0,0,0 for start of member.
-Keyin DL=0,0,39.5 for end of member.
-For Cardinal Point keyin 2 and dp to accept.
-Reset to backup and tentative snap to the base of first member.
-Keyin DL=6:11.5,0,0 for start and DL=0,0,39.5 for end.
-Set Cardinal Point to 8, dp to accept, resets to exit.
-Select PLACE MEMBER BEAM, snap to top of the first column and place a dp.
-Keyin DL=46.5,0,0 for the end of the member.
-Select 15 for Cardinal Point and dp to accept.
-Reset twice to exit command.

(4) Relocate top chord to correct position.

-Select the MOVE END ASSOCIATIVE command.
-Snap to right end of the top chord and accept.
-Keyin DL=0,0,7.5.
-dp to accept and reset to exit.

(5) Continue placing web members:

-Select PLACE MEMBER BRACE.
-Snap and dp at bottom of second column.
-Snap to bottom of first column and keyin DL=0,0,4.
-Accept default Orientation and Vector.
-At Orientation ? prompt give dp to accept.
-At End of Member prompt, snap to bottom of second column and keyin DL=0,0,8.
-Repeat procedure to place all web members. (Spacing varies see Appendix D)
-Reset twice to exit.

(6) Relocate end of second column.

-Set AEC associative move lock to Proportionality.
-Select MOVE END ASSOCIATIVE command.
-Snap to base of second column and accept.

-Keyin XY=2,0,0.
-dp to accept and reset to exit.

(7) Mirror copy placed members and nodes.

-Zoom out in the ISO view.
-Select MIRROR COPY command.
-Verify Component is set to Member and set Group to View.
-Accept highlighted group and keyin C for copy.
-Snap to the centerline of the truss in the Front View.
-Keyin DL=0,0,1 and dp to accept mirrored copy.
-Reset to exit.

(8) Modify Cardinal Points of copied columns.

-Select the Edit Cardinal point command.
-Follow prompts to modify the left column to CP=2 and the right column to CP=8.

(9) Place the bottom chord of the truss.

-Select PLACE MEMBER BEAM and snap to desired nodes on column one and two.
-Keyin a CP of 10 and dp to accept.
-Reset until section icon is oriented correctly, then place a dp.
-Reset to Exit.

(10) Place truss web members.

-Select PLACE MEMBER BRACE and place similar to column web members. Member sizes are shown in Appendix D.

(11) Set Boundary Conditions as done for the Rigid Frame.

(12) Set up Load Entry by selecting the CASE/COMB command and setting up as follows:

| NAME | LEVEL | COLOR |
|---|---|---|
| Body | 9 | 2 |
| Dead | 21 | 2 |
| Live | 22 | 4 |
| Cranerail | 23 | 1 |
| WindX | 24 | 7 |

(13) Set the load combinations similarly by selecting the CASE/COMB command and setting up as follows:

| NAME | COMBINATION |
| --- | --- |
| COMB1 | BODY+DEAD+LIVE |
| COMB2 | BODY+DEAD+LIVE+CRANERAIL |
| COMB3 | BODY+DEAD+LIVE+WINDX |
| COMB4 | BODY+DEAD+LIVE+CRANERAIL+WINDX |

-Set the Global Multiplier to 1.0 for combinations 1 and 2, and to .75 for combinations 3 and 4.

(14) Place loads on structure.

-Select PLACE LOADS CONCENTRATED NODAL.
-Follow the prompts to place the following loads:

| LOAD CASE | ORIENTATION | MAGNITUDE | GROUP |
| --- | --- | --- | --- |
| DEAD | 0,0,1 | -2.5 | TOP CHORD |
| LIVE | 0,0,1 | -1.5 | TOP CHORD |
| CRANERAIL | 0,0,1 | -5.0 | 3,9 BOTT CHORD |
| WINDX | 1,0,0 | 1.8 | TOP CHORD |

(15) Exit place loads tutorial and Stop and Exit IRM.

d. Execute Analysis:

(1) Add dead weight of structure in alpha environment.

-From the Analysis Main Menu keyin LLD.
-Follow prompts to place a BODY load of -0.49 in the Z direction for members 1:200.

(2) If the Analysis Setup is not complete at this point it should be entered now.

-From the alpha main menu keyin SCAN (model info scan).
-From the alpha main menu keyin MREP (model def. rpt).
-From the alpha main menu keyin RREP (results report).
-Configure reports and analysis as in other examples.

(3) Execute analysis by selecting appropriate options from the alphanumeric environment menus.

## 2.4 3D Aircraft Hanger

a. Description: The problem involves a 3D model of an aircraft hanger 93' x 195'. Vertical and lateral support is provided by four braced steel frames, while longitudinal support is provided by spandrel trusses and a braced frame at the end of the hanger. Concentrated loads are applied at various top and bottom chord panel points. See Appendix E for typical results output and a model sketch.

b. Solution Approach:

(1) To begin modeling the problem, first enter SMS to create a database:

-Select option #1, "Create Structural Model".
-Input a name for the model.
-Choose a model size.
-Choose model units.
-Select option #3, "Run SMS Graphics".
-Keyin project name and answer prompts to attach menus.

(2) Setup project parameters as follows:

-Select the ACTIVE PARAMS and PROJECT commands.
-Set UNITS to English
-Select STEEL for material.
-Select AISC for section table.
-Select A36 for grade.
-Reset to Retain and Exit "Active Parameters".
-Select FILE command.

(3) Use IGDS commands to lay out complex geometry prior to placing members. Place structural members into the database using SMS commands. A brief summary of member placement is as follows:

(4) To place columns:

-Select PLACE ELEMENT - X-SECTION "COLUMN".
-Keyin column section name.
-Snap to start of column IGDS graphic element and dp.
-Snap and dp at end of column.

(5) Place all beams and braces for one bent in a similar way. Copy all members of the created bent by:

-Fit Front View.
-Select COPY MEMBER - GROUP FENCE.
-Place fence around entire bent.
-dp to accept group or modify.
-Select the base of one column as start point.
-Snap to base of same column and keyin "DX=0,0,-z" to copy the bent "z" feet.
-Repeat procedure to copy all bents required.

(6) Place beams and braces for the spandrel trusses just as for the bent frames. Use the COPY GROUP command as well to fill in between all bents.

(7) When the structure is complete, use the CSD command to WRITE the model to a .BLU (blue) file. The .BLU file will be

used by IRM for analysis.

-Select the CSD command from Utilities.
-Select WRITE from the tutorial.
-Select Active Group command ALL.
-dp to accept group.
-Keyin or accept default for .BLU file.
-Reset for default origin.
-Exit tutorial at completion.
-Stop SMS and Exit.

c. Input Problem Data:

(1) To begin the IRM analysis of the model enter IRM:

-Select option #3, "Structural Products Interface".
-Enter a new jobname.
-Use default database.
-Toggle to desired model size with ENTER key.
-Use same length units used when creating the CSD.

(2) Import Common Structural Database:

-Select option #1,"Common Structural Database to IRM Conversion".
-Enter the name of the .BLU file used in SMS.
-Enter '0,0,0' for Node Tolerance.
-Enter '0' for Complete Model.
-Select option #1, Unrestrained Supports.
-Pin all connections when prompted.
-The IRM Main Menu will then return.

(3) Enter the Graphics Interface.

(4) Set Boundary Conditions:

-Select BC's command and CONSTRAINTS.
-dp and Reset until constraints appear as:
T1 T2 T3 /
-Select GROUP FENCE command and place fence around all column bases.

(5) Place loads: Refer to IRM manual for Load Placement commands.

d. Execute Analysis: If the Analysis Setup is not complete at this point it should be entered now. The member placement parameters and element types were placed into the database in SMS and imported to IRM previously. The structure may now be analyzed by selecting the ANALYZE command at the top of the AEC Menu or by entering the Alphanumeric Interface and executing the commands there.

## 3. Recommendations

### 3.1 Modeling Recommendations

a. Use of the Structural Modeling System (SMS) may simplify the creation of many models, particularly if using Version 8.8.2 of IRM. IGDS should be used to create the geometry of a complex structure and actual elements placed on the sketch once it is complete. This will make it easier to keep track of member orientations and help to keep the database clean.

b. It is recommended that a thin shell model be used in order to promote economy in the structures analyzed in 3D and to eliminate problems associated with converting from 2D to 3D.

c. When modeling a large structure the design file quickly becomes congested with elements and loads. The best way to alleviate this problem is to put members and separate load cases on different levels. In very large structures each group of members should be placed on a different level. When the model becomes too complex, some of the levels can be turned off. This becomes especially important when labeling member end releases, marked groups, member orientation, nodes, or members, since the display depth does not stop members in other planes from being labeled along with those in the current display. The user should plan his modeling sequence such that levels, colors, etc., are set prior to getting into any design file.

d. The use of seed files to preset material properties, output format, output requirements, and other common file attributes will greatly simplify the use of IRM.

### 3.2 Miscellaneous Recommendations

a. Make nodes large enough to be visible when using the FLASH command and the UID group. Select the FLASH, NODE, and UID commands to locate unstable nodes identified in the Unstable Node Report.

b. Never renumber nodes with the renumber UID command unless you are sending the model for third party processing and want to reduce the bandwidth. Renumbering will not relabel your model in a logical series or format. IRM will automatically renumber nodes internally to reduce the bandwidth but this will not affect your numbering scheme.

c. Utilize available warning reports and review them until you are confident in the accuracy of the model. Look for unstable nodes and watch for unusually large, or small, nodal translations or rotations, which may indicate a modeling problem.

d. Beware of the ROTATE PROPERTIES command as it rotates the section properties but not the cross-section. In IRM, the local member axis and the start and end of a member determine the top and bottom of that member, such as may be required for lateral bracing. Therefore, if the outside face of a building is to be the top side of some columns, such that the girt spacings will determine the lateral bracing spacing for strong axis bending, the columns on one side of the building will have to be placed from the bottom up, with the opposite side columns being placed from the top down.

e. Recognize the power of the active/inactive element concept. The edit command can be used to make parts of the structure active or inactive for analysis, which can be used to quickly isolate a part of the structure to view its behavior in a 2D model.

f. Beware the database rebuild command. It rebuilds the IRM database but not IRMD. Anything done in steel or concrete design will be lost.

# APPENDIX A

# GETTING STARTED

# APPENDIX A

## GETTING STARTED

Step #1 - Load all example files onto the system.
#2 - Login to the system.
#3 - Copy the seed file COESEED.* into files named:

YOUR_PROJECT_NAME.*

or accept the product default seed file when prompted in IRM.

#4 - -At the $ prompt, keyin IRM.
-Select Option #1, "Graphical Interface".
-Select Option #2, "Structural Model Generation".
-Keyin a Jobname (Design file w/o .DGN extension).
-If COESEED was used go to CONTINUE, else......
-Accept default or keyin seed file database.
-Toggle to correct model size.
-Move cursor to "(CONTINUE)" then hit Enter key.
-Keyin a job type description.
-Toggle model type to Thin Shell.
-Set desired type of Units.
-CONTINUE
-You will now be put into the design file.
#5 - dp or Reset for pull-down menus.
#6 - Attach table menu by reset or screen menu by placing a data point in any view but the Tutorial View.
#7 - Type AM=MENU,CM to attach IGDS menu.

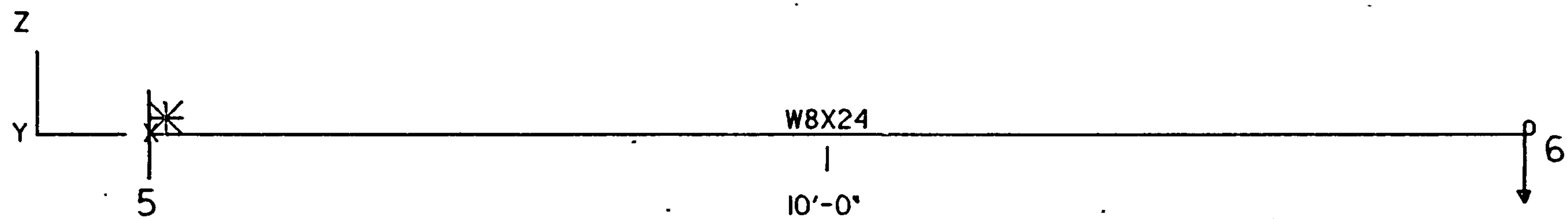
The example problems are in the following files:

| | |
|---|---|
| CANTILEVERED BEAM | - SPENCER.* |
| 2D RIGID FRAME | - BENT.* |
| 2D HANGER TRUSS | - COETRUSS.* |
| 3D AIRCRAFT HANGER | - HANGER.*<br>CSMHANG.* |

The seed file used for examples 2 and 4 was STEEL.* and for examples 1 and 3, COESEED.*. Output data for all example problems is in files of the form, PROJECT_NAME00i.PTR.

# APPENDIX B

## EXAMPLE NO. 1 - CANTILEVERED BEAM




CANTILEVERED BEAM

************************************************************************************

spencer
CANTILEVERED BEAM

************************************************************************************

IRM REV 8.8.3 OCT 10,1989 15:17
ANALYSIS NO.9 THIN SHELL PAGE 1

*** Units Definition ***

| Unit Group | Unit |
|---|---|
| 1 - Lengths | FEET |
| 2 - Element Properties | INCHES |
| 3 - Forces | KIPS |
| 4 - Angles | DEGREES |
| 5 - Displacements | INCHES |
| 6 - Masses | MASS |
| 7 - Time | SECONDS |
| 8 - Stress Forces | KIPS |

Vertical Axis = Z

Gravitational Constant (g) =32.2 FT /SEC /SEC

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spencer
CANTILEVERED BEAM

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IRM REV 8.8.3 OCT 10,1989 15:17
ANALYSIS NO.9 THIN SHELL PAGE 2

*** Material Property Tables ***

| Name/No. | Table Data | |
|---|---|---|
| A36 | Material Type | = ISOTROPIC |
| 1 | Modulus of Elasticity (E) | = 29000.0 ksi. |
| | Poisson's Ratio (v) | = 0.3 |
| | Shear Modulus (G) | = 11153.8457 ksi. |
| | Alpha | = 0.0 |
| | Weight Density | = 0.49 k/ft^3. |

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spencer
CANTILEVERED BEAM

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IRM REV 8.8.3 OCT 10,1989 15:17
ANALYSIS NO.9 THIN SHELL PAGE 3

*** Load Cases ***

| Name/No. | Table Data | |
|---|---|---|
| LC1 | Analysis type | = Static |
| 3 | Load case type | = Dead load |
| | Status | = Active |
| | Level | = 9 |
| | Color | = 2 |
| | Convert nodal loads to masses | = No |
| LC2 | Analysis type | = Static |
| 2 | Load case type | = Dead load |
| | Status | = Active |
| | Level | = 9 |
| | Color | = 2 |
| | Convert nodal loads to masses | = No |

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spencer
CANTILEVERED BEAM

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IRM REV 8.8.3 OCT 10,1989 15:17
ANALYSIS NO.9 THIN SHELL PAGE 4

*** Load Combinations ***

| Name/No. | Type | Print Results | Global Multiplier | Load Case Name | Load Case Multiplier |
|---|---|---|---|---|---|
| COMB1 | Linear | Yes | 1.0 | LC1 | 1.0 |
| 2 | | | | LC2 | 0.75 |

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spencer
CANTILEVERED BEAM

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IRM REV 8.8.3 OCT 10,1989 15:17
ANALYSIS NO.9 THIN SHELL PAGE 5

*** Nodal Loads ***

| Node Id/Label | Type | Loc Glob | Load Case | Load | Vector or Dof | Load Type |
|---|---|---|---|---|---|---|
| 6 | VEC | GLOB | LC2 | 1.000 | (0,0,-1) | FOR |

*****************************************************************************

spencer
CANTILEVERED BEAM

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IRM REV 8.8.3 OCT 10,1989 15:17
ANALYSIS NO.9 THIN SHELL PAGE 6

*** Line Element ***

| Element Id/Label | Element Type | A/I | Material Properties | Element Properties | Design Type | Shr/Fict Stiff | Rot Prop |
|---|---|---|---|---|---|---|---|
| 1 | BEAM | A | A36 | W8X24 | BEAM | NO | 0 |

Angle of Roll = 0.000
Nodes: Start = 5 End = 6
I-J Length = 10.000 Number of VMD Segments = 16
Non-Rigid Length = 10.000 Cardinal Point = 15
Physical Member Id = 1 Reflection Axis = None

```
*****************************************************************************

                              spencer
                          CANTILEVERED BEAM
*****************************************************************************
IRM REV   8.8.3                                    OCT 10,1989       15:17
ANALYSIS NO.9                 THIN SHELL                          PAGE 7


*** Line Element Loads ***

Element     Load                                 Load     Abs/  Location
Label/Id    Case      Type      Frame  Dir  (Velocity)  Rel   (Shape Factor)
---------------------------------------------------------------------------
      1     LC1       BODY      GLOBAL  Z      -0.490
```

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spencer
CANTILEVERED BEAM

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IRM Rev 8.8.3 OCT 6,1989 15:55:23
Analysis No. 7 Thin Shell Page 1

*** Displacements ***

| Node | Cas/Cmb | TX IN | TY IN | TZ IN | RX DEG | RY DEG | RZ DEG |
|---|---|---|---|---|---|---|---|
| 5 | LC1 3 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | LC2 2 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | COMB1 2 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 6 | LC1 3 | 0.0000 | 0.0000 | -0.0217 | 1.439e-08 | 0.0138 | 0.0000 |
| | LC2 2 | 0.0000 | 0.0000 | -0.2399 | 1.792e-07 | 0.1718 | 0.0000 |
| | COMB1 2 | 0.0000 | 0.0000 | -0.2016 | 1.488e-07 | 0.1426 | 0.0000 |

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spencer
CANTILEVERED BEAM

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IRM Rev 8.8.3 OCT 6,1989 15:55:24
Analysis No. 7 Thin Shell Page 2

*** Displacements ***

| Quantity | Limit | Value | Unit | Node | Ldcmb/Cs |
|---|---|---|---|---|---|
| TX | Max | 0.0000 | IN | 5 | LC1 3 |
| | Min | 0.0000 | IN | 5 | LC1 3 |
| TY | Max | 0.0000 | IN | 5 | LC1 3 |
| | Min | 0.0000 | IN | 5 | LC1 3 |
| TZ | Max | 0.0000 | IN | 5 | LC1 3 |
| | Min | -0.2399 | IN | 6 | LC2 2 |
| RX | Max | 1.792e-07 | DEG | 6 | LC2 2 |
| | Min | 0.0000 | DEG | 5 | LC1 3 |
| RY | Max | 0.1718 | DEG | 6 | LC2 2 |
| | Min | 0.0000 | DEG | 5 | LC1 3 |
| RZ | Max | 0.0000 | DEG | 5 | LC1 3 |
| | Min | 0.0000 | DEG | 5 | LC1 3 |

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spencer
CANTILEVERED BEAM

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IRM Rev 8.8.3 OCT 6,1989 15:55:24
Analysis No. 7 Thin Shell Page 3

*** Support Reactions ***

| Node | Cas/Cmb | FX KPS | FY KPS | FZ KPS | MX FT-KPS | MY FT-KPS | MZ FT-KPS |
|---|---|---|---|---|---|---|---|
| 5 | LC1 3 | | | | | | |
| | | 0.0000 | 0.0000 | 0.2409 | -1.256e-06 | -1.2046 | 0.0000 |
| | LC2 2 | | | | | | |
| | | 0.0000 | 0.0000 | 1.0000 | -1.043e-05 | -10.0000 | 0.0000 |
| | COMB1 2 | | | | | | |
| | | 0.0000 | 0.0000 | 0.9909 | -9.080e-06 | -8.7046 | 0.0000 |

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spencer
CANTILEVERED BEAM

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IRM Rev 8.8.3 OCT 6,1989 15:55:24
Analysis No. 7 Thin Shell Page 4

*** Support Reactions ***

| Quantity | Limit | Value | Unit | Node | Ldcmb/Cs |
|---|---|---|---|---|---|
| FX | Max | 0.0000 | KPS | 5 | LC1 3 |
| | Min | 0.0000 | KPS | 5 | LC1 3 |
| FY | Max | 0.0000 | KPS | 5 | LC1 3 |
| | Min | 0.0000 | KPS | 5 | LC1 3 |
| FZ | Max | 1.0000 | KPS | 5 | LC2 2 |
| | Min | 0.2409 | KPS | 5 | LC1 3 |
| MX | Max | -1.256e-06 | FT-KPS | 5 | LC1 3 |
| | Min | -1.043e-05 | FT-KPS | 5 | LC2 2 |
| MY | Max | -1.2046 | FT-KPS | 5 | LC1 3 |
| | Min | -10.0000 | FT-KPS | 5 | LC2 2 |
| MZ | Max | 0.0000 | FT-KPS | 5 | LC1 3 |
| | Min | 0.0000 | FT-KPS | 5 | LC1 3 |

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spencer
CANTILEVERED BEAM

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IRM Rev 8.8.3 OCT 6,1989 15:55:24
Analysis No. 7 Thin Shell Page 5

*** Line Element End Actions ***

| Elem | Cas/Cmb Node | FX KPS | FY KPS | FZ KPS | MX FT-KPS | MY FT-KPS | MZ FT-KPS |
|---|---|---|---|---|---|---|---|
| 1 | | | | | | | |
| | LC1 3 | | | | | | |
| | 5 | 0.0000 | 0.2409 | 0.0000 | 0.0000 | 0.0000 | 1.2046 |
| | 6 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | LC2 2 | | | | | | |
| | 5 | 0.0000 | 1.0000 | 0.0000 | 9.095e-13 | 0.0000 | 10.0000 |
| | 6 | 0.0000 | -1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | COMB1 2 | | | | | | |
| | 5 | 0.0000 | 0.9909 | 0.0000 | 6.821e-13 | 0.0000 | 8.7046 |
| | 6 | 0.0000 | -0.7500 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

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spencer
CANTILEVERED BEAM

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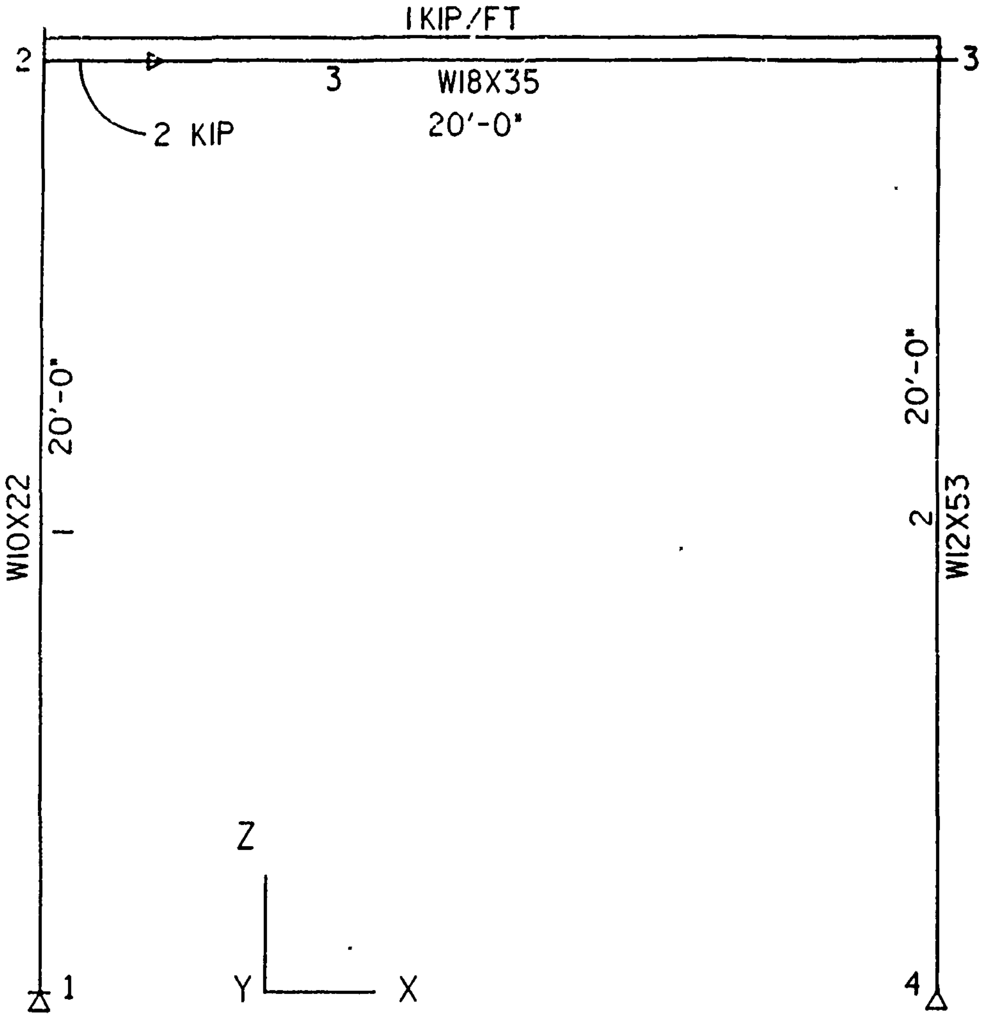
IRM Rev 8.8.3 OCT 6,1989 15:55:25
Analysis No. 7 Thin Shell Page 6

*** Line Element End Actions ***

| Quantity | Limit | Value | Unit | Elem | Node | Ldcmb/Cs |
|---|---|---|---|---|---|---|
| FX | Max | 0.0000 | KPS | 1 | 5 | LC1 3 |
| | Min | 0.0000 | KPS | 1 | 5 | LC1 3 |
| FY | Max | 1.0000 | KPS | 1 | 5 | LC2 2 |
| | Min | -1.0000 | KPS | 1 | 6 | LC2 2 |
| FZ | Max | 0.0000 | KPS | 1 | 5 | LC1 3 |
| | Min | 0.0000 | KPS | 1 | 5 | LC1 3 |
| MX | Max | 9.095e-13 | FT-KPS | 1 | 5 | LC2 2 |
| | Min | 0.0000 | FT-KPS | 1 | 5 | LC1 3 |
| MY | Max | 0.0000 | FT-KPS | 1 | 5 | LC1 3 |
| | Min | 0.0000 | FT-KPS | 1 | 5 | LC1 3 |
| MZ | Max | 10.0000 | FT-KPS | 1 | 5 | LC2 2 |
| | Min | 0.0000 | FT-KPS | | 6 | LC2 2 |

# APPENDIX C

## EXAMPLE NO. 2 - 2D RIGID FRAME




# 2D RIGID FRAME

******************************************************************************

BENT
RIGID FRAME
******************************************************************************
IRM REV 8.8.3 OCT 6,1989 09:20
ANALYSIS NO.11 THIN SHELL PAGE 1

*** Units Definition ***

| Unit Group | Unit |
|---|---|
| 1 - Lengths | FEET |
| 2 - Element Properties | INCHES |
| 3 - Forces | KIPS |
| 4 - Angles | DEGREES |
| 5 - Displacements | INCHES |
| 6 - Masses | MASS |
| 7 - Time | SECONDS |
| 8 - Stress Forces | KIPS |

Vertical Axis = Z

Gravitational Constant (g) =32.2 FT /SEC /SEC

******************************************************************************

BENT
RIGID FRAME
******************************************************************************
IRM REV 8.8.3 OCT 6,1989 09:20
ANALYSIS NO.11 THIN SHELL PAGE 2

*** Material Property Tables ***

| Name/No. | Table Data | |
|---|---|---|
| A36 | Material Type | = ISOTROPIC |
| 1 | Modulus of Elasticity (E) | = 29000.0 ksi. |
| | Poisson's Ratio (v) | = 0.3 |
| | Shear Modulus (G) | = 11153.8457 ksi. |
| | Alpha | = 0.0 |

*******************************************************************************

BENT
RIGID FRAME

*******************************************************************************

IRM REV 8.8.3 OCT 6,1989 09:20
ANALYSIS NO.11 THIN SHELL PAGE 3

*** Load Cases ***

| Name/No. | Table Data | |
|---|---|---|
| LC1 | Analysis type | = Static |
| 1 | Load case type | = Dead load |
| | Status | = Active |
| | Level | = 9 |
| | Color | = 7 |
| | Convert nodal loads to masses | = No |
| LC2 | Analysis type | = Static |
| 2 | Load case type | = Live load |
| | Status | = Active |
| | Level | = 9 |
| | Color | = 4 |
| | Convert nodal loads to masses | = No |

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BENT
RIGID FRAME

*******************************************************************************

IRM REV 8.8.3 OCT 6,1989 09:20
ANALYSIS NO.11 THIN SHELL PAGE 4

*** Load Combinations ***

| Name/No. | Type | Print Results | Global Multiplier | Load Case Name | Load Case Multiplier |
|---|---|---|---|---|---|
| COMB1 | Linear | Yes | 1.0 | LC1 | 1.0 |
| 1 | | | | LC2 | 1.0 |

***************************************************************************

BENT
RIGID FRAME

***************************************************************************

IRM REV 8.8.3 OCT 6,1989 09:20
ANALYSIS NO.11 THIN SHELL PAGE 5

*** Nodal Loads ***

| Node Id/Label | Loc Type | Glob | Load Case | Load | Vector or Dof | Load Type |
|---|---|---|---|---|---|---|
| 2 | VEC | GLOB | LC2 | 2.000 | (1,0,0) | FOR |

***************************************************************************

BENT
RIGID FRAME

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IRM REV 8.8.3 OCT 6,1989 09:20
ANALYSIS NO.11 THIN SHELL PAGE 6

*** Line Element ***

| Element Id/Label | Element Type | A/I | Material Properties | Element Properties | Design Type | Shr/Fict Stiff | Rot Prop |
|---|---|---|---|---|---|---|---|
| 1 | BEAM | A | A36 | W10X22 | COLUMN | NO | 0 |

Angle of Roll = 0.000
Nodes: Start = 1 End = 2
I-J Length = 20.000 Number of VMD Segments = 2
Non-Rigid Length = 20.000 Cardinal Point = 15
Physical Member Id = 1 Reflection Axis = None

| Element Id/Label | Element Type | A/I | Material Properties | Element Properties | Design Type | Shr/Fict Stiff | Rot Prop |
|---|---|---|---|---|---|---|---|
| 2 | BEAM | A | A36 | W12X53 | COLUMN | NO | 0 |

Angle of Roll = 0.000
Nodes: Start = 3 End = 4
I-J Length = 20.000 Number of VMD Segments = 2
Non-Rigid Length = 20.000 Cardinal Point = 15
Physical Member Id = 2 Reflection Axis = None

| Element Id/Label | Element Type | A/I | Material Properties | Element Properties | Design Type | Shr/Fict Stiff | Rot Prop |
|---|---|---|---|---|---|---|---|
| 3 | BEAM | A | A36 | W18X35 | BEAM | NO | 0 |

Angle of Roll = 0.000
Nodes: Start = 2 End = 3
I-J Length = 20.000 Number of VMD Segments = 16
Non-Rigid Length = 20.000 Cardinal Point = 15
Physical Member Id = 3 Reflection Axis = None

*** Line Element Loads ***

| Element Label/Id | Load Case | Type | Frame | Dir | Load (Velocity) | Abs/ Rel | Location (Shape Factor) |
|---|---|---|---|---|---|---|---|
| 3 | LC1 | DIST | GLOBAL | Z | -1.000 | | |

*********************************************************************************

BENT
RIGID FRAME

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IRM Rev 8.8.3 OCT 6,1989 09:21:09
Analysis No. 12 Thin Shell Page 1

*** Displacements ***

| Node | Cas/Cmb | TX IN | TY IN | TZ IN | RX DEG | RY DEG | RZ DEG |
|---|---|---|---|---|---|---|---|
| 1 | LC1 1 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.2967 | 0.0000 |
| | LC2 2 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.2394 | 0.0000 |
| | COMB1 1 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.9427 | 0.0000 |
| 2 | LC1 1 | -0.5860 | 0.0000 | -0.0128 | 0.0000 | 0.1737 | 0.0000 |
| | LC2 2 | 3.3984 | 0.0000 | 2.550e-03 | 0.0000 | -0.0448 | 0.0000 |
| | COMB1 1 | 2.8125 | 0.0000 | -0.0102 | 0.0000 | 0.1288 | 0.0000 |
| 3 | LC1 1 | -0.5860 | 0.0000 | -5.305e-03 | 0.0000 | -0.1772 | 0.0000 |
| | LC2 2 | 3.3970 | 0.0000 | -1.061e-03 | 0.0000 | 0.1209 | 0.0000 |
| | COMB1 1 | 2.8110 | 0.0000 | -6.366e-03 | 0.0000 | -0.0563 | 0.0000 |
| 4 | LC1 1 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.1212 | 0.0000 |
| | LC2 2 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.1560 | 0.0000 |
| | COMB1 1 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0348 | 0.0000 |

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BENT
RIGID FRAME

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IRM Rev 8.8.3 OCT 6,1989 09:21:10
Analysis No. 12 Thin Shell Page 2

*** Displacements ***

| Quantity | Limit | Value | Unit | Node | Ldcmb/Cs |
|---|---|---|---|---|---|
| TX | Max | 3.3984 | IN | 2 | LC2 2 |
| | Min | -0.5860 | IN | 3 | LC1 1 |
| TY | Max | 0.0000 | IN | 1 | LC1 1 |
| | Min | 0.0000 | IN | 1 | LC1 1 |
| TZ | Max | 2.550e-03 | IN | 2 | LC2 2 |
| | Min | -0.0128 | IN | 2 | LC1 1 |
| RX | Max | 0.0000 | DEG | 1 | LC1 1 |
| | Min | 0.0000 | DEG | 1 | LC1 1 |
| RY | Max | 1.2394 | DEG | 1 | LC2 2 |
| | Min | -0.2967 | DEG | 1 | LC1 1 |
| RZ | Max | 0.0000 | DEG | 1 | LC1 1 |
| | Min | 0.0000 | DEG | 1 | LC1 1 |

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BENT
RIGID FRAME

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IRM Rev 8.8.3 OCT 6,1989 09:21:10
Analysis No. 12 Thin Shell Page 3

*** Support Reactions ***

| Node | Cas/Cmb | FX KPS | FY KPS | FZ KPS | MX FT-KPS | MY FT-KPS | MZ FT-KPS |
|---|---|---|---|---|---|---|---|
| 1 | LC1 1 | | | | | | |
| | | 0.0942 | 0.0000 | 10.0000 | 0.0000 | 0.0000 | 0.0000 |
| | LC2 2 | | | | | | |
| | | -0.2573 | 0.0000 | -2.0000 | 0.0000 | 0.0000 | 0.0000 |
| | COMB1 1 | | | | | | |
| | | -0.1631 | 0.0000 | 8.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | LC1 1 | | | | | | |
| | | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | LC2 2 | | | | | | |
| | | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | COMB1 1 | | | | | | |
| | | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 3 | LC1 1 | | | | | | |
| | | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | LC2 2 | | | | | | |
| | | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | COMB1 1 | | | | | | |
| | | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 4 | LC1 1 | | | | | | |
| | | -0.0942 | 0.0000 | 10.0000 | 0.0000 | 0.0000 | 0.0000 |
| | LC2 2 | | | | | | |
| | | -1.7427 | 0.0000 | 2.0000 | 0.0000 | 0.0000 | 0.0000 |
| | COMB1 1 | | | | | | |
| | | -1.8369 | 0.0000 | 12.0000 | 0.0000 | 0.0000 | 0.0000 |

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BENT
RIGID FRAME

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IRM Rev 8.8.3 OCT 6,1989 09:21:11
Analysis No. 12 Thin Shell Page 4

*** Support Reactions ***

| Quantity | Limit | Value | Unit | Node | Locmb/Cs |
|---|---|---|---|---|---|
| FX | Max | 0.0942 | KPS | 1 | LC1 1 |
| | Min | -1.8369 | KPS | 4 | COMB1 1 |
| FY | Max | 0.0000 | KPS | 1 | LC1 1 |
| | Min | 0.0000 | KPS | 1 | LC1 1 |
| FZ | Max | 12.0000 | KPS | 4 | COMB1 1 |
| | Min | -2.0000 | KPS | 1 | LC2 2 |
| MX | Max | 0.0000 | FT-KPS | 1 | LC1 1 |
| | Min | 0.0000 | FT-KPS | 1 | LC1 1 |
| MY | Max | 0.0000 | FT-KPS | 1 | LC1 1 |
| | Min | 0.0000 | FT-KPS | 1 | LC1 1 |
| MZ | Max | 0.0000 | FT-KPS | 1 | LC1 1 |
| | Min | 0.0000 | FT-KPS | 1 | LC1 1 |

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BENT
RIGID FRAME

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IRM Rev 8.8.3 OCT 6,1989 09:21:11
Analysis No. 12 Thin Shell Page 5

*** Line Element End Actions ***

| Elem | Cas/Cmb Node | FX KPS | FY KPS | FZ KPS | MX FT-KPS | MY FT-KPS | MZ FT-KPS |
|---|---|---|---|---|---|---|---|
| 1 | | | | | | | |
| | LC1 1 | | | | | | |
| | 1 | 10.0000 | 0.0000 | 0.0942 | 0.0000 | 0.0000 | 0.0000 |
| | 2 | -10.0000 | 0.0000 | -0.0942 | 0.0000 | -1.8846 | 0.0000 |
| | LC2 2 | | | | | | |
| | 1 | -2.0000 | 0.0000 | -0.2573 | 0.0000 | 8.327e-17 | 0.0000 |
| | 2 | 2.0000 | 0.0000 | 0.2573 | 0.0000 | 5.1457 | 0.0000 |
| | COMB1 1 | | | | | | |
| | 1 | 8.0000 | 0.0000 | -0.1631 | 0.0000 | 8.327e-17 | 0.0000 |
| | 2 | -8.0000 | 0.0000 | 0.1631 | 0.0000 | 3.2612 | 0.0000 |
| 2 | | | | | | | |
| | LC1 1 | | | | | | |
| | 3 | 10.0000 | 0.0000 | 0.0942 | 0.0000 | -1.8846 | 0.0000 |
| | 4 | -10.0000 | 0.0000 | -0.0942 | 0.0000 | 0.0000 | 0.0000 |
| | LC2 2 | | | | | | |
| | 3 | 2.0000 | 0.0000 | 1.7427 | 0.0000 | -34.8543 | 0.0000 |
| | 4 | -2.0000 | 0.0000 | -1.7427 | 0.0000 | 1.776e-15 | 0.0000 |
| | COMB1 1 | | | | | | |
| | 3 | 12.0000 | 0.0000 | 1.8369 | 0.0000 | -36.7388 | 0.0000 |
| | 4 | -12.0000 | 0.0000 | -1.8369 | 0.0000 | 1.776e-15 | 0.0000 |
| 3 | | | | | | | |
| | LC1 1 | | | | | | |
| | 2 | 0.0942 | 10.0000 | 0.0000 | 0.0000 | 0.0000 | 1.8846 |
| | 3 | -0.0942 | 10.0000 | 0.0000 | 0.0000 | 0.0000 | -1.8846 |
| | LC2 2 | | | | | | |
| | 2 | 1.7427 | -2.0000 | 0.0000 | 0.0000 | 0.0000 | -5.1457 |
| | 3 | -1.7427 | 2.0000 | 0.0000 | 0.0000 | 0.0000 | -34.8543 |
| | COMB1 1 | | | | | | |
| | 2 | 1.8369 | 8.0000 | 0.0000 | 0.0000 | 0.0000 | -3.2612 |
| | 3 | -1.8369 | 12.0000 | 0.0000 | 0.0000 | 0.0000 | -36.7388 |

*****************************************************************************

BENT
RIGID FRAME

*****************************************************************************

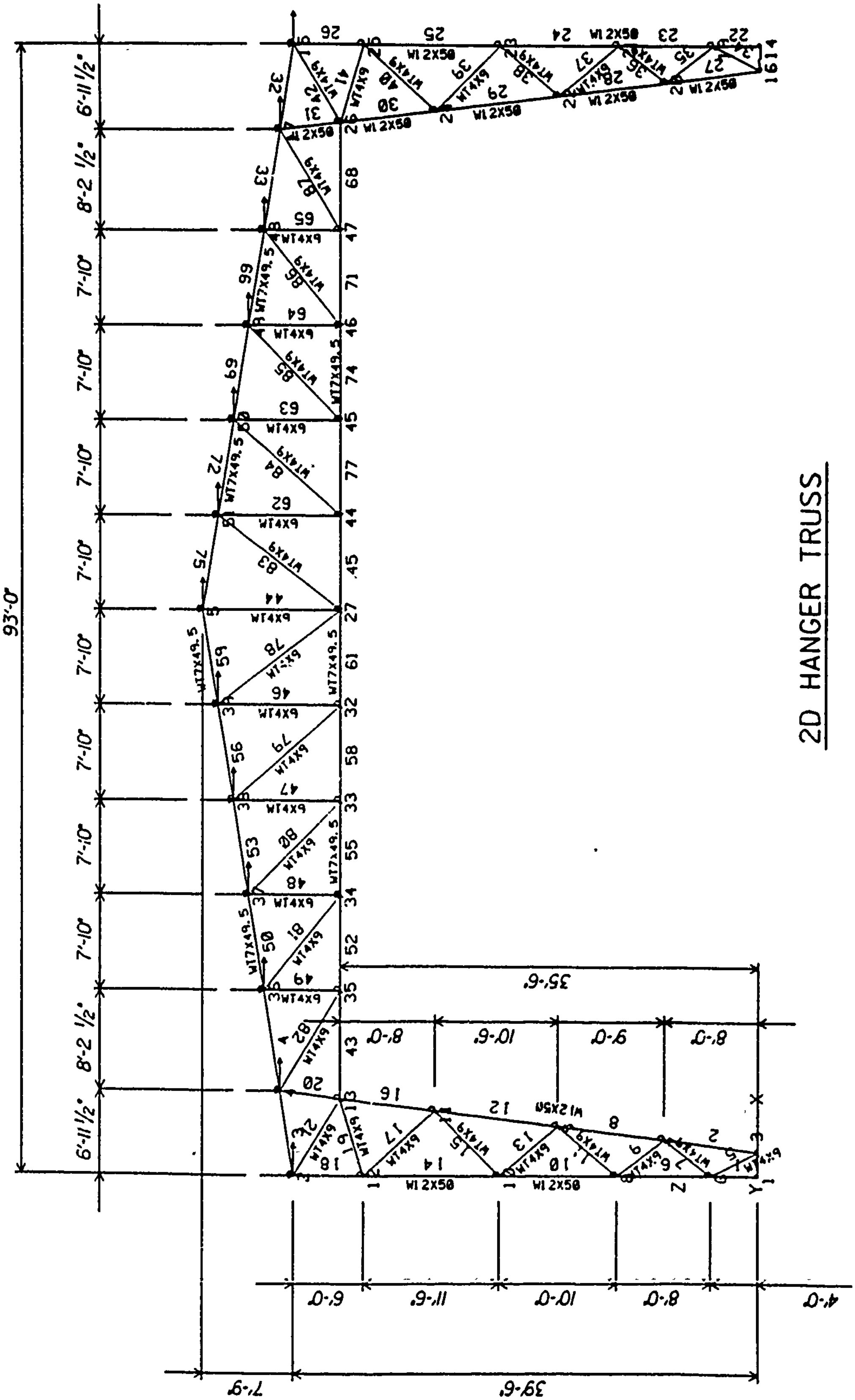
IRM Rev 8.8.3 OCT 6,1989 09:21:12
Analysis No. 12 Thin Shell Page 6

*** Line Element End Actions ***

| Quantity | Limit | Value | Unit | Elem | Node | Ldcmb/Cs |
|---|---|---|---|---|---|---|
| FX | Max | 12.0000 | KPS | 2 | 3 | COMB1 1 |
| | Min | -12.0000 | KPS | 2 | 4 | COMB1 1 |
| FY | Max | 12.0000 | KPS | 3 | 3 | COMB1 1 |
| | Min | -2.0000 | KPS | 3 | 2 | LC2 2 |
| FZ | Max | 1.8369 | KPS | 2 | 3 | COMB1 1 |
| | Min | -1.8369 | KPS | 2 | 4 | COMB1 1 |
| MX | Max | 0.0000 | FT-KPS | 1 | 1 | LC1 1 |
| | Min | 0.0000 | FT-KPS | 1 | 1 | LC1 1 |
| MY | Max | 5.1457 | FT-KPS | 1 | 2 | LC2 2 |
| | Min | -36.7388 | FT-KPS | 2 | 3 | COMB1 1 |
| MZ | Max | 1.8846 | FT-KPS | 3 | 2 | LC1 1 |
| | Min | -36.7388 | FT-KPS | 3 | 3 | COMB1 1 |

# APPENDIX D

## EXAMPLE NO. 3. - 2D HANGER TRUSS




2D HANGER TRUSS

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COETRUSS
2-D Aircraft Hanger Example

********************************************************************************

IRM REV 8.8.3 OCT 11,1989 13:38
ANALYSIS NO.8 THIN SHELL PAGE 1

*** Units Definition ***

| Unit Group | Unit |
|---|---|
| 1 - Lengths | FEET |
| 2 - Element Properties | INCHES |
| 3 - Forces | KIPS |
| 4 - Angles | DEGREES |
| 5 - Displacements | INCHES |
| 6 - Masses | MASS |
| 7 - Time | SECONDS |
| 8 - Stress Forces | KIPS |

Vertical Axis = Z

Gravitational Constant (g) =32.2 FT /SEC /SEC

********************************************************************************

COETRUSS
2-D Aircraft Hanger Example

********************************************************************************

IRM REV 8.8.3 OCT 11,1989 13:38
ANALYSIS NO.8 THIN SHELL PAGE 2

*** Material Property Tables ***

| Name/No. | Table Data | |
|---|---|---|
| A36 | Material Type | = ISOTROPIC |
| 1 | Modulus of Elasticity (E) | = 29000.0 ksi. |
| | Poisson's Ratio (v) | = 0.3 |
| | Shear Modulus (G) | = 11153.8457 ksi. |
| | Alpha | = 0.0 |

*** Load Cases ***

| Name/No. | Table Data | |
|---|---|---|
| BODY | Analysis type | = Static |
| 1 | Load case type | = Dead load |
| | Status | = Active |
| | Level | = 9 |
| | Color | = 2 |
| | Convert nodal loads to masses | = No |
| DEAD | Analysis type | = Static |
| 2 | Load case type | = Dead load |
| | Status | = Active |
| | Level | = 21 |
| | Color | = 2 |
| | Convert nodal loads to masses | = No |
| LIVE | Analysis type | = Static |
| 3 | Load case type | = Dead load |
| | Status | = Active |
| | Level | = 22 |
| | Color | = 4 |
| | Convert nodal loads to masses | = No |
| CRANERAIL | Analysis type | = Static |
| 4 | Load case type | = Dead load |
| | Status | = Active |
| | Level | = 23 |
| | Color | = 1 |
| | Convert nodal loads to masses | = No |
| WINDX | Analysis type | = Static |
| 5 | Load case type | = Dead load |
| | Status | = Active |
| | Level | = 24 |
| | Color | = 7 |
| | Convert nodal loads to masses | = No |

*** Load Combinations ***

| Name/No. | Type | Print Results | Global Multiplier | Load Case Name | Load Case Multiplier |
|---|---|---|---|---|---|
| COMB1 | Linear | Yes | 1.0 | BODY | 1.0 |
| 1 | | | | DEAD | 1.0 |
| | | | | LIVE | 1.0 |
| COMB2 | Linear | Yes | 1.0 | BODY | 1.0 |
| 2 | | | | DEAD | 1.0 |
| | | | | LIVE | 1.0 |
| | | | | CRANERAIL | 1.0 |
| COMB3 | Linear | Yes | 0.75 | BODY | 1.0 |
| 3 | | | | DEAD | 1.0 |
| | | | | LIVE | 1.0 |
| | | | | WINDX | 1.0 |
| COMB4 | Linear | Yes | 0.75 | BODY | 1.0 |
| 4 | | | | DEAD | 1.0 |
| | | | | LIVE | 1.0 |
| | | | | CRANERAIL | 1.0 |
| | | | | WINDX | 1.0 |

*** Nodal Loads ***

| Node Id/Label | Type | Loc Glob | Load Case | Load | Vector or Dof | Load Type |
|---|---|---|---|---|---|---|
| 2 | VEC | GLOB | DEAD | -2.500 | (0,0,1) | FOR |
| | VEC | GLOB | LIVE | -1.500 | (0,0,1) | FOR |
| | VEC | GLOB | WINDX | 1.800 | (1,0,0) | FOR |
| 4 | VEC | GLOB | DEAD | -2.500 | (0,0,1) | FOR |
| | VEC | GLOB | LIVE | -1.500 | (0,0,1) | FOR |
| | VEC | GLOB | WINDX | 1.800 | (1,0,0) | FOR |
| 5 | VEC | GLOB | DEAD | -2.500 | (0,0,1) | FOR |
| | VEC | GLOB | LIVE | -1.500 | (0,0,1) | FOR |
| | VEC | GLOB | WINDX | 1.800 | (1,0,0) | FOR |
| 15 | VEC | GLOB | DEAD | -2.500 | (0,0,1) | FOR |
| | VEC | GLOB | LIVE | -1.500 | (0,0,1) | FOR |
| | VEC | GLOB | WINDX | 1.800 | (1,0,0) | FOR |
| 17 | VEC | GLOB | DEAD | -2.500 | (0,0,1) | FOR |
| | VEC | GLOB | LIVE | -1.500 | (0,0,1) | FOR |
| | VEC | GLOB | WINDX | 1.800 | (1,0,0) | FOR |
| 34 | VEC | GLOB | CRANERAIL | -5.000 | (0,0,1) | FOR |
| 36 | VEC | GLOB | DEAD | -2.500 | (0,0,1) | FOR |
| | VEC | GLOB | LIVE | -1.500 | (0,0,1) | FOR |
| | VEC | GLOB | WINDX | 1.800 | (1,0,0) | FOR |
| 37 | VEC | GLOB | DEAD | -2.500 | (0,0,1) | FOR |
| | VEC | GLOB | LIVE | -1.500 | (0,0,1) | FOR |
| | VEC | GLOB | WINDX | 1.800 | (1,0,0) | FOR |
| 38 | VEC | GLOB | DEAD | -2.500 | (0,0,1) | FOR |
| | VEC | GLOB | LIVE | -1.500 | (0,0,1) | FOR |
| | VEC | GLOB | WINDX | 1.800 | (1,0,0) | FOR |
| 39 | VEC | GLOB | DEAD | -2.500 | (0,0,1) | FOR |
| | VEC | GLOB | LIVE | -1.500 | (0,0,1) | FOR |
| | VEC | GLOB | WINDX | 1.800 | (1,0,0) | FOR |
| 46 | VEC | GLOB | CRANERAIL | -5.000 | (0,0,1) | FOR |
| 48 | VEC | GLOB | DEAD | -2.500 | (0,0,1) | FOR |
| | VEC | GLOB | LIVE | -1.500 | (0,0,1) | FOR |
| | VEC | GLOB | WINDX | 1.800 | (1,0,0) | FOR |
| 49 | VEC | GLOB | DEAD | -2.500 | (0,0,1) | FOR |
| | VEC | GLOB | LIVE | -1.500 | (0,0,1) | FOR |
| | VEC | GLOB | WINDX | 1.800 | (1,0,0) | FOR |
| 50 | VEC | GLOB | DEAD | -2.500 | (0,0,1) | FOR |
| | VEC | GLOB | LIVE | -1.500 | (0,0,1) | FOR |
| | VEC | GLOB | WINDX | 1.800 | (1,0,0) | FOR |
| 51 | VEC | GLOB | DEAD | -2.500 | (0,0,1) | FOR |
| | VEC | GLOB | LIVE | -1.500 | (0,0,1) | FOR |
| | VEC | GLOB | WINDX | 1.800 | (1,0,0) | FOR |

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COETRUSS
2-D Aircraft Hanger Example

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IRM Rev 8.8.3 OCT 12,1989 07:57:25
Analysis No. 10 Thin Shell Page 1

*** Support Reactions ***

| Node | Cas/Cmb | FX KPS | FY KPS | FZ KPS | MX FT-KPS | MY FT-KPS | MZ FT-KPS |
|---|---|---|---|---|---|---|---|
| 1 | BODY 1 | 0.7325 | 0.0000 | 5.7545 | 0.0000 | 0.0000 | 0.0000 |
| | DEAD 2 | 1.2678 | 0.0000 | 10.8800 | 0.0000 | 0.0000 | 0.0000 |
| | LIVE 3 | 0.7607 | 0.0000 | 6.5280 | 0.0000 | 0.0000 | 0.0000 |
| | CRANERAIL 4 | 0.3968 | 0.0000 | 3.7462 | 0.0000 | 0.0000 | 0.0000 |
| | WINDX 5 | -3.7230 | 0.0000 | -87.2170 | 0.0000 | 0.0000 | 0.0000 |
| | COMB1 1 | 2.7610 | 0.0000 | 23.1625 | 0.0000 | 0.0000 | 0.0000 |
| | COMB2 2 | 3.1577 | 0.0000 | 26.9087 | 0.0000 | 0.0000 | 0.0000 |
| | COMB3 3 | -0.7215 | 0.0000 | -48.0408 | 0.0000 | 0.0000 | 0.0000 |
| | COMB4 4 | -0.4239 | 0.0000 | -45.2312 | 0.0000 | 0.0000 | 0.0000 |
| 3 | BODY 1 | 0.2962 | 0.0000 | 3.9778 | 0.0000 | 0.0000 | 0.0000 |
| | DEAD 2 | 1.0472 | 0.0000 | 5.3700 | 0.0000 | 0.0000 | 0.0000 |
| | LIVE 3 | 0.6283 | 0.0000 | 3.2220 | 0.0000 | 0.0000 | 0.0000 |
| | CRANERAIL 4 | 0.5225 | 0.0000 | 1.2538 | 0.0000 | 0.0000 | 0.0000 |
| | WINDX 5 | -7.9770 | 0.0000 | 79.8219 | 0.0000 | 0.0000 | 0.0000 |
| | COMB1 1 | 1.9718 | 0.0000 | 12.5697 | 0.0000 | 0.0000 | 0.0000 |
| | COMB2 2 | 2.4943 | 0.0000 | 13.8235 | 0.0000 | 0.0000 | 0.0000 |
| | COMB3 3 | -4.5039 | 0.0000 | 69.2938 | 0.0000 | 0.0000 | 0.0000 |
| | COMB4 4 | -4.1121 | 0.0000 | 70.2341 | 0.0000 | 0.0000 | 0.0000 |
| 14 | BODY 1 | -0.7325 | 0.0000 | 5.7545 | 0.0000 | 0.0000 | 0.0000 |
| | DEAD 2 | -1.2678 | 0.0000 | 10.8800 | 0.0000 | 0.0000 | 0.0000 |

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COETRUSS
2-D Aircraft Hanger Example

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IRM Rev 8.8.3 OCT 12,1989 07:57:28
Analysis No. 10 Thin Shell Page 2

*** Support Reactions ***

| Node | Cas/Cmb | FX KPS | FY KPS | FZ KPS | MX FT-KPS | MY FT-KPS | MZ FT-KPS |
|---|---|---|---|---|---|---|---|
| 14 | LIVE 3 | | | | | | |
| | | -0.7607 | 0.0000 | 6.5280 | 0.0000 | 0.0000 | 0.0000 |
| | CRANERAIL 4 | | | | | | |
| | | -0.3968 | 0.0000 | 3.7462 | 0.0000 | 0.0000 | 0.0000 |
| | WINDX 5 | | | | | | |
| | | -3.7229 | 0.0000 | 87.2167 | 0.0000 | 0.0000 | 0.0000 |
| | COMB1 1 | | | | | | |
| | | -2.7609 | 0.0000 | 23.1625 | 0.0000 | 0.0000 | 0.0000 |
| | COMB2 2 | | | | | | |
| | | -3.1577 | 0.0000 | 26.9087 | 0.0000 | 0.0000 | 0.0000 |
| | COMB3 3 | | | | | | |
| | | -4.8629 | 0.0000 | 82.7844 | 0.0000 | 0.0000 | 0.0000 |
| | COMB4 4 | | | | | | |
| | | -5.1605 | 0.0000 | 85.5941 | 0.0000 | 0.0000 | 0.0000 |
| 16 | BODY 1 | | | | | | |
| | | -0.2962 | 0.0000 | 3.9778 | 0.0000 | 0.0000 | 0.0000 |
| | DEAD 2 | | | | | | |
| | | -1.0472 | 0.0000 | 5.3700 | 0.0000 | 0.0000 | 0.0000 |
| | LIVE 3 | | | | | | |
| | | -0.6283 | 0.0000 | 3.2220 | 0.0000 | 0.0000 | 0.0000 |
| | CRANERAIL 4 | | | | | | |
| | | -0.5225 | 0.0000 | 1.2538 | 0.0000 | 0.0000 | 0.0000 |
| | WINDX 5 | | | | | | |
| | | -7.9771 | 0.0000 | -79.8217 | 0.0000 | 0.0000 | 0.0000 |
| | COMB1 1 | | | | | | |
| | | -1.9718 | 0.0000 | 12.5697 | 0.0000 | 0.0000 | 0.0000 |
| | COMB2 2 | | | | | | |
| | | -2.4943 | 0.0000 | 13.8235 | 0.0000 | 0.0000 | 0.0000 |
| | COMB3 3 | | | | | | |
| | | -7.4617 | 0.0000 | -50.4390 | 0.0000 | 0.0000 | 0.0000 |
| | COMB4 4 | | | | | | |
| | | -7.8536 | 0.0000 | -49.4986 | 0.0000 | 0.0000 | 0.0000 |

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COETRUSS
2-D Aircraft Hanger Example

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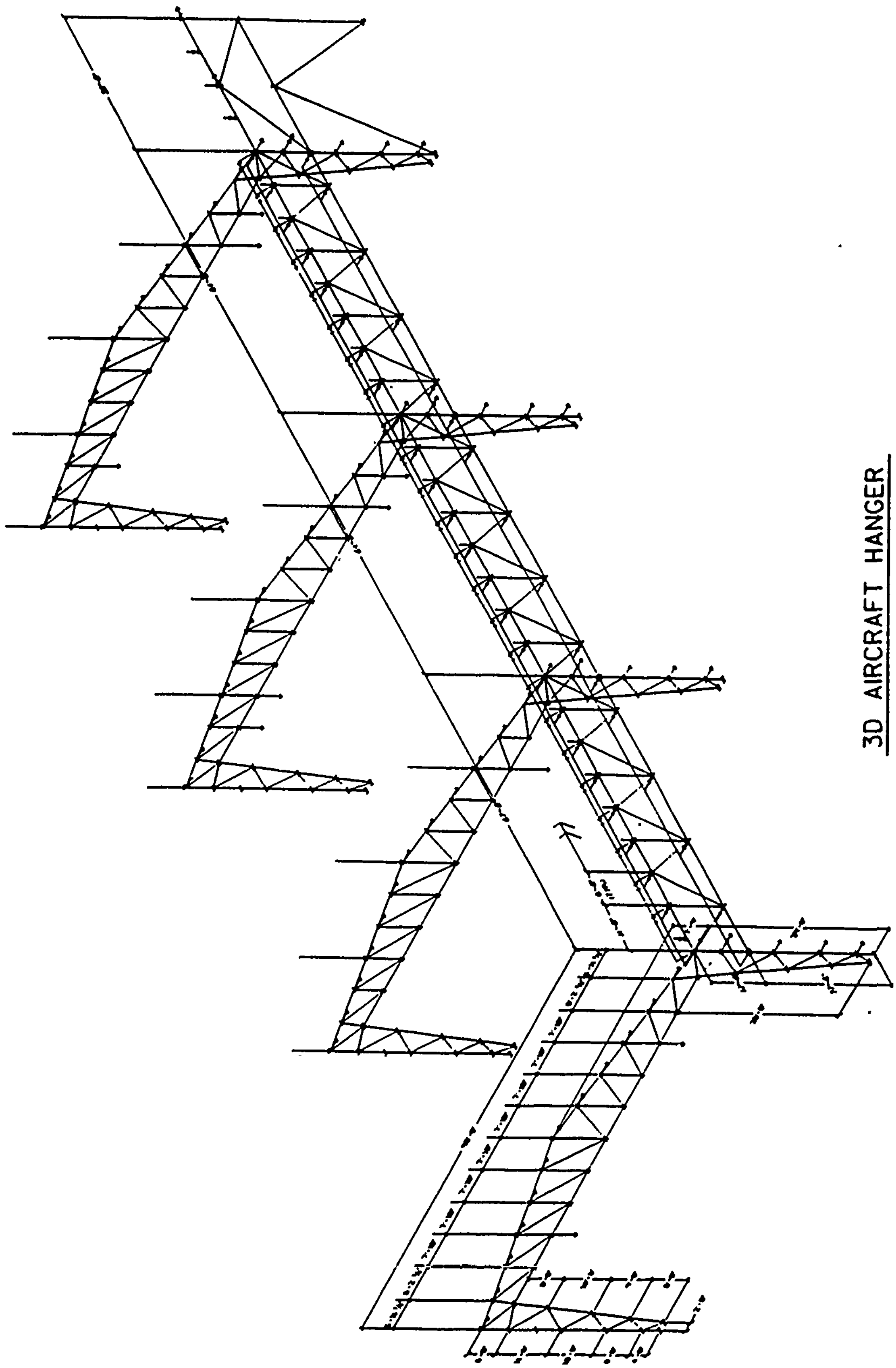
IRM Rev 8.8.3 OCT 12,1989 07:57:33
Analysis No. 10 Thin Shell Page 3

*** Support Reactions ***

| Quantity | Limit | Value | Unit | Node | Ldcmb/Cs |
|---|---|---|---|---|---|
| FX | Max | 3.1577 | KPS | 1 | COMB2 2 |
| | Min | -7.9771 | KPS | 16 | WINDX 5 |
| FY | Max | 0.0000 | KPS | 1 | BODY 1 |
| | Min | 0.0000 | KPS | 1 | BODY 1 |
| FZ | Max | 87.2167 | KPS | 14 | WINDX 5 |
| | Min | -87.2170 | KPS | 1 | WINDX 5 |
| MX | Max | 0.0000 | FT-KPS | 1 | BODY 1 |
| | Min | 0.0000 | FT-KPS | 1 | BODY 1 |
| MY | Max | 0.0000 | FT-KPS | 1 | BODY 1 |
| | Min | 0.0000 | FT-KPS | 1 | BODY 1 |
| MZ | Max | 0.0000 | FT-KPS | 1 | BODY 1 |
| | Min | 0.0000 | FT-KPS | 1 | BODY 1 |

APPENDIX E

EXAMPLE NO. 4 - 3D AIRCRAFT HANGER



3D AIRCRAFT HANGER

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HANGER
3D ANALYSIS OF AN AIRCRAFT HANGER

*******************************************************************************

IRM REV 8.8.3 OCT 6,1989 09:32
ANALYSIS NO.9 THIN SHELL PAGE 1

*** Units Definition ***

| Unit Group | Unit |
|---|---|
| 1 - Lengths | FEET |
| 2 - Element Properties | INCHES |
| 3 - Forces | KIPS |
| 4 - Angles | DEGREES |
| 5 - Displacements | INCHES |
| 6 - Masses | MASS |
| 7 - Time | SECONDS |
| 8 - Stress Forces | KIPS |

Vertical Axis = Y

Gravitational Constant (g) =32.2 FT /SEC /SEC

*******************************************************************************

HANGER
3D ANALYSIS OF AN AIRCRAFT HANGER

*******************************************************************************

IRM REV 8.8.3 OCT 6,1989 09:32
ANALYSIS NO.9 THIN SHELL PAGE 2

*** Material Property Tables ***

| Name/No. | Table Data | |
|---|---|---|
| STEEL | Material Type | = ISOTROPIC |
| 1 | Modulus of Elasticity (E) | = 30000.002 ksi. |
| | Poisson's Ratio (v) | = 0.3 |
| | Shear Modulus (G) | = 11538.4619 ksi. |
| | Alpha | = 0.0 |

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HANGER

3D ANALYSIS OF AN AIRCRAFT HANGER

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IRM REV 8.8.3 OCT 6,1989 09:32

ANALYSIS NO.9 THIN SHELL PAGE 3

*** Load Cases ***

| Name/No. | Table Data | |
|---|---|---|
| LC1 | Analysis type | = Static |
| 1 | Load case type | = Dead load |
| | Status | = Active |
| | Level | = 9 |
| | Color | = 2 |
| | Convert nodal loads to masses | = No |
| LC2 | Analysis type | = Static |
| 2 | Load case type | = Dead load |
| | Status | = Active |
| | Level | = 9 |
| | Color | = 2 |
| | Convert nodal loads to masses | = No |
| LC4 | Analysis type | = Static |
| 3 | Load case type | = Dead load |
| | Status | = Active |
| | Level | = 9 |
| | Color | = 2 |
| | Convert nodal loads to masses | = No |
| LC3 | Analysis type | = Static |
| 4 | Load case type | = Dead load |
| | Status | = Active |
| | Level | = 9 |
| | Color | = 2 |
| | Convert nodal loads to masses | = No |
| LC5 | Analysis type | = Static |
| 5 | Load case type | = Dead load |
| | Status | = Active |
| | Level | = 9 |
| | Color | = 2 |
| | Convert nodal loads to masses | = No |

*** Load Combinations ***

None

*** Nodal Loads ***

| Node Id/Label | Type | Loc Glob | Load Case | Load | Vector or Dof | Load Type |
|---|---|---|---|---|---|---|
| 2 | VEC | GLOB | LC3 | 1.200 | (0,-1,0) | FOR |
| 3 | VEC | GLOB | LC3 | 1.200 | (0,-1,0) | FOR |
| 4 | VEC | GLOB | LC3 | 1.200 | (0,-1,0) | FOR |
| 5 | VEC | GLOB | LC4 | -6.000 | (-1,0,0) | FOR |
| 6 | VEC | GLOB | LC3 | 1.200 | (0,-1,0) | FOR |
| | VEC | GLOB | LC3 | 6.000 | (0,-1,0) | FOR |
| 7 | VEC | GLOB | LC3 | 1.740 | (0,-1,0) | FOR |
| 9 | VEC | GLOB | LC3 | 1.200 | (0,-1,0) | FOR |
| 10 | VEC | GLOB | LC3 | 1.200 | (0,-1,0) | FOR |
| 11 | VEC | GLOB | LC3 | 1.200 | (0,-1,0) | FOR |
| 12 | VEC | GLOB | LC4 | -6.000 | (-1,0,0) | FOR |
| 13 | VEC | GLOB | LC3 | 1.200 | (0,-1,0) | FOR |
| | VEC | GLOB | LC3 | 6.000 | (0,-1,0) | FOR |
| 14 | VEC | GLOB | LC3 | 1.740 | (0,-1,0) | FOR |
| 21 | VEC | GLOB | LC1 | -18.050 | (0,0,1) | FOR |
| | VEC | GLOB | LC3 | 1.740 | (0,-1,0) | FOR |
| 28 | VEC | GLOB | LC1 | -18.050 | (0,0,1) | FOR |
| | VEC | GLOB | LC3 | 1.740 | (0,-1,0) | FOR |
| 34 | VEC | GLOB | LC3 | 1.740 | (0,-1,0) | FOR |
| 40 | VEC | GLOB | LC3 | 1.740 | (0,-1,0) | FOR |
| 41 | VEC | GLOB | LC3 | 1.740 | (0,-1,0) | FOR |
| 42 | VEC | GLOB | LC1 | -36.100 | (0,0,1) | FOR |
| | VEC | GLOB | LC3 | 1.740 | (0,-1,0) | FOR |
| 43 | VEC | GLOB | LC3 | 1.740 | (0,-1,0) | FOR |
| 44 | VEC | GLOB | LC3 | 1.740 | (0,-1,0) | FOR |
| 45 | VEC | GLOB | LC1 | -36.100 | (0,0,1) | FOR |
| | VEC | GLOB | LC3 | 1.740 | (0,-1,0) | FOR |
| 46 | VEC | GLOB | LC3 | 1.740 | (0,-1,0) | FOR |
| 47 | VEC | GLOB | LC3 | 1.740 | (0,-1,0) | FOR |
| 48 | VEC | GLOB | LC1 | -36.100 | (0,0,1) | FOR |
| | VEC | GLOB | LC3 | 1.740 | (0,-1,0) | FOR |
| 49 | VEC | GLOB | LC3 | 1.740 | (0,-1,0) | FOR |
| 57 | VEC | GLOB | LC2 | 18.500 | (0,0,-1) | FOR |
| 64 | VEC | GLOB | LC3 | 1.740 | (0,-1,0) | FOR |
| 70 | VEC | GLOB | LC3 | 1.740 | (0,-1,0) | FOR |
| 71 | VEC | GLOB | LC3 | 1.740 | (0,-1,0) | FOR |
| 72 | VEC | GLOB | LC1 | -36.100 | (0,0,1) | FOR |
| | VEC | GLOB | LC3 | 1.740 | (0,-1,0) | FOR |
| 73 | VEC | GLOB | LC3 | 1.740 | (0,-1,0) | FOR |
| 74 | VEC | GLOB | LC3 | 1.740 | (0,-1,0) | FOR |

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HANGER
3D ANALYSIS OF AN AIRCRAFT HANGER

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IRM REV 8.8.3 OCT 6,1989 09:32
ANALYSIS NO.9 THIN SHELL PAGE 6

*** Nodal Loads ***

| Node Id/Label | Type | Loc Glob | Load Case | Load | Vector or Dof | Load Type |
|---|---|---|---|---|---|---|
| 75 | VEC | GLOB | LC1 | -36.100 | (0,0,1) | FOR |
| | VEC | GLOB | LC3 | 1.740 | (0,-1,0) | FOR |
| 76 | VEC | GLOB | LC3 | 1.740 | (0,-1,0) | FOR |
| 77 | VEC | GLOB | LC3 | 1.740 | (0,-1,0) | FOR |
| 78 | VEC | GLOB | LC1 | -36.100 | (0,0,1) | FOR |
| | VEC | GLOB | LC3 | 1.740 | (0,-1,0) | FOR |
| 79 | VEC | GLOB | LC3 | 1.740 | (0,-1,0) | FOR |
| 80 | VEC | GLOB | LC1 | 9.000 | (0,0,-1) | FOR |
| 81 | VEC | GLOB | LC2 | 9.250 | (0,0,-1) | FOR |
| 87 | VEC | GLOB | LC2 | 9.250 | (0,0,-1) | FOR |
| 88 | VEC | GLOB | LC1 | 9.000 | (0,0,-1) | FOR |
| 90 | VEC | GLOB | LC3 | 1.200 | (0,-1,0) | FOR |
| 91 | VEC | GLOB | LC3 | 1.200 | (0,-1,0) | FOR |
| 92 | VEC | GLOB | LC3 | 1.200 | (0,-1,0) | FOR |
| 93 | VEC | GLOB | LC4 | -6.000 | (-1,0,0) | FOR |
| 94 | VEC | GLOB | LC3 | 1.200 | (0,-1,0) | FOR |
| | VEC | GLOB | LC3 | 6.000 | (0,-1,0) | FOR |
| 95 | VEC | GLOB | LC3 | 1.740 | (0,-1,0) | FOR |
| 102 | VEC | GLOB | LC1 | -18.050 | (0,0,1) | FOR |
| | VEC | GLOB | LC3 | 1.740 | (0,-1,0) | FOR |
| 108 | VEC | GLOB | LC3 | 1.740 | (0,-1,0) | FOR |
| 114 | VEC | GLOB | LC3 | 1.740 | (0,-1,0) | FOR |
| 115 | VEC | GLOB | LC3 | 1.740 | (0,-1,0) | FOR |
| 116 | VEC | GLOB | LC1 | -36.100 | (0,0,1) | FOR |
| | VEC | GLOB | LC3 | 1.740 | (0,-1,0) | FOR |
| 117 | VEC | GLOB | LC3 | 1.740 | (0,-1,0) | FOR |
| 118 | VEC | GLOB | LC3 | 1.740 | (0,-1,0) | FOR |
| 119 | VEC | GLOB | LC1 | -36.100 | (0.0,1) | FOR |
| | VEC | GLOB | LC3 | 1.740 | (0,-1,0) | FOR |
| 120 | VEC | GLOB | LC3 | 1.740 | (0,-1,0) | FOR |
| 121 | VEC | GLOB | LC3 | 1.740 | (0,-1,0) | FOR |
| 122 | VEC | GLOB | LC1 | -36.100 | (0,0,1) | FOR |
| | VEC | GLOB | LC3 | 1.740 | (0,-1,0) | FOR |
| 123 | VEC | GLOB | LC3 | 1.740 | (0,-1,0) | FOR |
| 124 | VEC | GLOB | LC1 | 9.000 | (0,0,-1) | FOR |
| 131 | VEC | GLOB | LC2 | 18.500 | (0,0,-1) | FOR |
| 132 | VEC | GLOB | LC1 | 9.000 | (0,0,-1) | FOR |
| 133 | VEC | GLOB | LC1 | -2.300 | (0,0,1) | FOR |
| 134 | VEC | GLOB | LC1 | -2.300 | (0,0,1) | FOR |
| 135 | VEC | GLOB | LC1 | -2.300 | (0,0,1) | FOR |

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HANGER
3D ANALYSIS OF AN AIRCRAFT HANGER

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*** Nodal Loads ***

| Node Id/Label | Type | Loc Glob | Load Case | Load | Vector or Dof | Load Type |
|---|---|---|---|---|---|---|
| 136 | VEC | GLOB | LC1 | -2.300 | (0,0,1) | FOR |
| 137 | VEC | GLOB | LC1 | -2.300 | (0,0,1) | FOR |
| 138 | VEC | GLOB | LC1 | -2.300 | (0,0,1) | FOR |
| 139 | VEC | GLOB | LC1 | -2.300 | (0,0,1) | FOR |
| 144 | VEC | GLOB | LC1 | -2.300 | (0,0,1) | FOR |
| 145 | VEC | GLOB | LC1 | -2.300 | (0,0,1) | FOR |
| 146 | VEC | GLOB | LC1 | -2.300 | (0,0,1) | FOR |
| 147 | VEC | GLOB | LC1 | -2.300 | (0,0,1) | FOR |
| 148 | VEC | GLOB | LC1 | -2.300 | (0,0,1) | FOR |
| 149 | VEC | GLOB | LC1 | -2.300 | (0,0,1) | FOR |
| 150 | VEC | GLOB | LC1 | -2.300 | (0,0,1) | FOR |
| 155 | VEC | GLOB | LC1 | -2.300 | (0,0,1) | FOR |
| 156 | VEC | GLOB | LC1 | -2.300 | (0,0,1) | FOR |
| 157 | VEC | GLOB | LC1 | -2.300 | (0,0,1) | FOR |
| 158 | VEC | GLOB | LC1 | -2.300 | (0,0,1) | FOR |
| 159 | VEC | GLOB | LC1 | -2.300 | (0,0,1) | FOR |
| 160 | VEC | GLOB | LC1 | -2.300 | (0,0,1) | FOR |
| 161 | VEC | GLOB | LC1 | -2.300 | (0,0,1) | FOR |
| 166 | VEC | GLOB | LC3 | 1.740 | (0,-1,0) | FOR |
| 167 | VEC | GLOB | LC4 | -6.000 | (-1,0,0) | FOR |
| 169 | VEC | GLOB | LC3 | 1.200 | (0,-1,0) | FOR |
| 170 | VEC | GLOB | LC3 | 1.200 | (0,-1,0) | FOR |
| 171 | VEC | GLOB | LC3 | 1.200 | (0,-1,0) | FOR |
| 172 | VEC | GLOB | LC3 | 1.200 | (0,-1,0) | FOR |
| | VEC | GLOB | LC3 | 6.000 | (0,-1,0) | FOR |
| 179 | VEC | GLOB | LC1 | -18.050 | (0,0,1) | FOR |
| | VEC | GLOB | LC3 | 1.740 | (0,-1,0) | FOR |
| 185 | VEC | GLOB | LC3 | 1.740 | (0,-1,0) | FOR |
| 191 | VEC | GLOB | LC3 | 1.740 | (0,-1,0) | FOR |
| 192 | VEC | GLOB | LC3 | 1.740 | (0,-1,0) | FOR |
| 193 | VEC | GLOB | LC1 | -36.100 | (0,0,1) | FOR |
| | VEC | GLOB | LC3 | 1.740 | (0,-1,0) | FOR |
| 194 | VEC | GLOB | LC3 | 1.740 | (0,-1,0) | FOR |
| 195 | VEC | GLOB | LC3 | 1.740 | (0,-1,0) | FOR |
| 196 | VEC | GLOB | LC1 | -36.100 | (0,0,1) | FOR |
| | VEC | GLOB | LC3 | 1.740 | (0,-1,0) | FOR |
| 197 | VEC | GLOB | LC3 | 1.740 | (0,-1,0) | FOR |
| 198 | VEC | GLOB | LC3 | 1.740 | (0,-1,0) | FOR |
| 199 | VEC | GLOB | LC1 | -36.100 | (0,0,1) | FOR |
| | VEC | GLOB | LC3 | 1.740 | (0,-1,0) | FOR |

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3D ANALYSIS OF AN AIRCRAFT HANGER

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*** Nodal Loads ***

| Node Id/Label | Type | Loc Glob | Load Case | Load | Vector or Dof | Load Type |
|---|---|---|---|---|---|---|
| 200 | VEC | GLOB | LC3 | 1.740 | (0,-1,0) | FOR |
| 202 | VEC | GLOB | LC2 | 9.250 | (0,0,-1) | FOR |
| 208 | VEC | GLOB | LC2 | 9.250 | (0,0,-1) | FOR |
| 212 | VEC | GLOB | LC1 | -2.300 | (0,0,1) | FOR |
| 213 | VEC | GLOB | LC1 | -2.300 | (0,0,1) | FOR |

*** Line Element Loads ***

| Element Label/Id | Load Case | Type | Frame | Dir | Load (Velocity) | Abs/ Rel | Location (Shape Factor) |
|---|---|---|---|---|---|---|---|
| 244 | LC4 | DIST | GLOBAL | X | 0.120 | | |
| | LC5 | DIST | GLOBAL | Y | -0.120 | | |
| 245 | LC4 | DIST | GLOBAL | X | 0.120 | | |
| | LC5 | DIST | GLOBAL | Y | -0.120 | | |
| 246 | LC4 | DIST | GLOBAL | X | 0.120 | | |
| | LC5 | DIST | GLOBAL | Y | -0.120 | | |
| 247 | LC4 | DIST | GLOBAL | X | 0.120 | | |
| | LC5 | DIST | GLOBAL | Y | -0.120 | | |
| 248 | LC4 | DIST | GLOBAL | X | 0.120 | | |
| | LC5 | DIST | GLOBAL | Y | -0.120 | | |
| 249 | LC4 | DIST | GLOBAL | X | 0.120 | | |
| | LC5 | DIST | GLOBAL | Y | -0.120 | | |
| 250 | LC4 | DIST | GLOBAL | X | 0.120 | | |
| | LC5 | DIST | GLOBAL | Y | -0.120 | | |
| 251 | LC4 | DIST | GLOBAL | X | 0.120 | | |
| | LC5 | DIST | GLOBAL | Y | -0.120 | | |
| 252 | LC5 | DIST | GLOBAL | Y | -0.120 | | |
| 253 | LC5 | DIST | GLOBAL | Y | -0.120 | | |
| 254 | LC5 | DIST | GLOBAL | Y | -0.120 | | |
| 255 | LC5 | DIST | GLOBAL | Y | -0.120 | | |
| 256 | LC5 | DIST | GLOBAL | Y | -0.120 | | |
| 269 | LC4 | DIST | GLOBAL | X | 0.120 | | |
| | LC5 | DIST | GLOBAL | Y | -0.120 | | |
| 270 | LC4 | DIST | GLOBAL | X | 0.120 | | |
| | LC5 | DIST | GLOBAL | Y | -0.120 | | |

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HANGER
3D ANALYSIS OF AN AIRCRAFT HANGER

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*** Line Element Loads ***

| Element Label/Id | Load Case | Type | Frame | Dir | Load (Velocity) | Abs/ Rel | Location (Shape Factor) |
|---|---|---|---|---|---|---|---|
| 271 | LC4 | DIST | GLOBAL | X | 0.120 | | |
| | LC5 | DIST | GLOBAL | Y | -0.120 | | |
| 272 | LC4 | DIST | GLOBAL | X | 0.120 | | |
| | LC5 | DIST | GLOBAL | Y | -0.120 | | |
| 273 | LC4 | DIST | GLOBAL | X | 0.120 | | |
| | LC5 | DIST | GLOBAL | Y | -0.120 | | |
| 274 | LC4 | DIST | GLOBAL | X | 0.120 | | |
| | LC5 | DIST | GLOBAL | Y | -0.120 | | |
| 275 | LC4 | DIST | GLOBAL | X | 0.120 | | |
| | LC5 | DIST | GLOBAL | Y | -0.120 | | |
| 276 | LC4 | DIST | GLOBAL | X | 0.120 | | |
| | LC5 | DIST | GLOBAL | Y | -0.120 | | |
| 277 | LC5 | DIST | GLOBAL | Y | -0.120 | | |
| 278 | LC5 | DIST | GLOBAL | Y | -0.120 | | |
| 279 | LC5 | DIST | GLOBAL | Y | -0.120 | | |
| 280 | LC5 | DIST | GLOBAL | Y | -0.120 | | |
| 281 | LC5 | DIST | GLOBAL | Y | -0.120 | | |
| 294 | LC4 | DIST | GLOBAL | X | 0.120 | | |
| | LC5 | DIST | GLOBAL | Y | -0.120 | | |
| 295 | LC4 | DIST | GLOBAL | X | 0.120 | | |
| | LC5 | DIST | GLOBAL | Y | -0.120 | | |
| 296 | LC4 | DIST | GLOBAL | X | 0.120 | | |
| | LC5 | DIST | GLOBAL | Y | -0.120 | | |
| 297 | LC4 | DIST | GLOBAL | X | 0.120 | | |
| | LC5 | DIST | GLOBAL | Y | -0.120 | | |

*** Line Element Loads ***

| Element Label/Id | Load Case | Type | Frame | Dir | Load (Velocity) | Abs/ Rel | Location (Shape Factor) |
|---|---|---|---|---|---|---|---|
| 298 | LC4 | DIST | GLOBAL | X | 0.120 | | |
| | LC5 | DIST | GLOBAL | Y | -0.120 | | |
| 299 | LC4 | DIST | GLOBAL | X | 0.120 | | |
| | LC5 | DIST | GLOBAL | Y | -0.120 | | |
| 300 | LC4 | DIST | GLOBAL | X | 0.120 | | |
| | LC5 | DIST | GLOBAL | Y | -0.120 | | |
| 301 | LC5 | DIST | GLOBAL | Y | -0.120 | | |
| 302 | LC5 | DIST | GLOBAL | Y | -0.120 | | |
| 303 | LC5 | DIST | GLOBAL | Y | -0.120 | | |
| 304 | LC5 | DIST | GLOBAL | Y | -0.120 | | |
| 316 | LC1 | CONCEN | GLOBAL | Z | -2.300 | ABS | 3.000 |
| | LC4 | DIST | GLOBAL | X | 0.120 | | |
| | LC5 | DIST | GLOBAL | Y | -0.120 | | |
| 318 | LC5 | DIST | GLOBAL | Y | -0.120 | | |
| 402 | LC1 | CONCEN | GLOBAL | Z | -2.300 | ABS | 8.000 |
| | LC4 | DIST | GLOBAL | X | 0.120 | | |
| 403 | LC1 | CONCEN | GLOBAL | Z | -2.300 | ABS | 8.000 |
| | LC4 | DIST | GLOBAL | X | 0.120 | | |

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HANGER
3D ANALYSIS OF AN AIRCRAFT HANGER

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*** Support Reactions ***

| Node | Cas/Cmb | FX KPS | FY KPS | FZ KPS | MX FT-KPS | MY FT-KPS | MZ FT-KPS |
|---|---|---|---|---|---|---|---|
| 1 | LC1 1 | | | | | | |
| | | -3.764e-03 | 0.1414 | 51.5898 | 0.0000 | 0.0000 | 0.0000 |
| | LC2 2 | | | | | | |
| | | 3.174e-05 | 0.0632 | 1.7657 | 0.0000 | 0.0000 | 0.0000 |
| | LC4 3 | | | | | | |
| | | -0.1724 | -1.444e-04 | -0.0654 | 0.0000 | 0.0000 | 0.0000 |
| | LC3 4 | | | | | | |
| | | 2.469e-03 | -0.3515 | 144.2092 | 0.0000 | 0.0000 | 0.0000 |
| | LC5 5 | | | | | | |
| | | 1.273e-04 | -0.3722 | 76.3472 | 0.0000 | 0.0000 | 0.0000 |
| 8 | LC1 1 | | | | | | |
| | | 3.237e-03 | 0.1618 | 57.4144 | 0.0000 | 0.0000 | 0.0000 |
| | LC2 2 | | | | | | |
| | | 8.334e-06 | 0.0222 | 7.3836 | 0.0000 | 0.0000 | 0.0000 |
| | LC4 3 | | | | | | |
| | | -0.1475 | -1.083e-03 | -0.5122 | 0.0000 | 0.0000 | 0.0000 |
| | LC3 4 | | | | | | |
| | | 3.066e-03 | -0.3494 | 144.0016 | 0.0000 | 0.0000 | 0.0000 |
| | LC5 5 | | | | | | |
| | | 5.061e-04 | -0.3566 | 73.1910 | 0.0000 | 0.0000 | 0.0000 |
| 15 | LC1 1 | | | | | | |
| | | -9.354e-07 | -0.1412 | 51.4570 | 0.0000 | 0.0000 | 0.0000 |
| | LC2 2 | | | | | | |
| | | 6.193e-06 | 0.0200 | 13.2128 | 0.0000 | 0.0000 | 0.0000 |
| | LC4 3 | | | | | | |
| | | 2.759e-05 | 2.413e-05 | 9.909e-03 | 0.0000 | 0.0000 | 0.0000 |
| | LC3 4 | | | | | | |
| | | -9.794e-07 | -0.3922 | -138.0613 | 0.0000 | 0.0000 | 0.0000 |
| | LC5 5 | | | | | | |
| | | -1.161e-03 | -0.2009 | -69.8883 | 0.0000 | 0.0000 | 0.0000 |
| 21 | LC1 1 | | | | | | |
| | | 4.583e-06 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | LC2 2 | | | | | | |
| | | -3.758e-05 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | LC4 3 | | | | | | |
| | | -2.100e-04 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | LC3 4 | | | | | | |
| | | 6.553e-06 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | LC5 5 | | | | | | |
| | | 7.034e-03 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

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HANGER

3D ANALYSIS OF AN AIRCRAFT HANGER

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Analysis No. 10 Thin Shell Page 2

*** Support Reactions ***

| Node | Cas/Cmb | FX KPS | FY KPS | FZ KPS | MX FT-KPS | MY FT-KPS | MZ FT-KPS |
|---|---|---|---|---|---|---|---|
| 22 | LC1 1 | -9.635e-07 | -0.1630 | 58.1963 | 0.0000 | 0.0000 | 0.0000 |
| | LC2 2 | 4.711e-06 | -0.0215 | 7.5825 | 0.0000 | 0.0000 | 0.0000 |
| | LC4 3 | 2.155e-05 | 1.952e-04 | 0.0795 | 0.0000 | 0.0000 | 0.0000 |
| | LC3 4 | -9.229e-07 | -0.3905 | -137.7014 | 0.0000 | 0.0000 | 0.0000 |
| | LC5 5 | 9.187e-04 | -0.1922 | -66.9686 | 0.0000 | 0.0000 | 0.0000 |
| 28 | LC1 1 | 6.576e-06 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | LC2 2 | -2.856e-05 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | LC4 3 | -1.587e-04 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | LC3 4 | 6.225e-06 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | LC5 5 | -5.556e-03 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 29 | LC1 1 | -5.190e-07 | -11.2074 | 20.7408 | 0.0000 | 0.0000 | 0.0000 |
| | LC2 2 | -8.131e-08 | -2.0223 | -9.1136 | 0.0000 | 0.0000 | 0.0000 |
| | LC4 3 | 3.620e-05 | -1.149e-03 | -8.243e-03 | 0.0000 | 0.0000 | 0.0000 |
| | LC3 4 | -5.173e-07 | 15.5225 | 130.2448 | 0.0000 | 0.0000 | 0.0000 |
| | LC5 5 | 3.716e-05 | 7.8543 | 66.6324 | 0.0000 | 0.0000 | 0.0000 |
| 35 | LC1 1 | 5.190e-07 | 11.2074 | 20.8444 | 0.0000 | 0.0000 | 0.0000 |
| | LC2 2 | 8.131e-08 | 1.9604 | 12.6537 | 0.0000 | 0.0000 | 0.0000 |
| | LC4 3 | -3.620e-05 | 1.267e-03 | -0.0852 | 0.0000 | 0.0000 | 0.0000 |
| | LC3 4 | 5.173e-07 | 18.6406 | -136.4078 | 0.0000 | 0.0000 | 0.0000 |
| | LC5 5 | -3.716e-05 | 10.1058 | -73.1204 | 0.0000 | 0.0000 | 0.0000 |

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3D ANALYSIS OF AN AIRCRAFT HANGER

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Analysis No. 10 Thin Shell Page 3

*** Support Reactions ***

| Node | Cas/Cmb | FX KPS | FY KPS | FZ KPS | MX FT-KPS | MY FT-KPS | MZ FT-KPS |
|---|---|---|---|---|---|---|---|
| 59 | LC1 1 | -5.995e-07 | -13.0001 | 23.0209 | 0.0000 | 0.0000 | 0.0000 |
| | LC2 2 | -7.615e-08 | -2.0135 | 1.6720 | 0.0000 | 0.0000 | 0.0000 |
| | LC4 3 | 2.608e-05 | -9.241e-03 | -0.0667 | 0.0000 | 0.0000 | 0.0000 |
| | LC3 4 | -4.419e-07 | 15.5244 | 129.8627 | 0.0000 | 0.0000 | 0.0000 |
| | LC5 5 | -3.489e-05 | 7.5448 | 63.8318 | 0.0000 | 0.0000 | 0.0000 |
| 65 | LC1 1 | 5.995e-07 | 13.0009 | 22.2235 | 0.0000 | 0.0000 | 0.0000 |
| | LC2 2 | 7.615e-08 | 1.9911 | 1.8389 | 0.0000 | 0.0000 | 0.0000 |
| | LC4 3 | -2.608e-05 | 9.895e-03 | -0.6552 | 0.0000 | 0.0000 | 0.0000 |
| | LC3 4 | 4.419e-07 | 18.6360 | -135.7733 | 0.0000 | 0.0000 | 0.0000 |
| | LC5 5 | 3.489e-05 | 9.7073 | -70.0318 | 0.0000 | 0.0000 | 0.0000 |
| 89 | LC1 1 | -0.0255 | 0.1572 | 56.0116 | 0.0000 | 0.0000 | 0.0000 |
| | LC2 2 | -2.314e-05 | 0.0640 | 1.6259 | 0.0000 | 0.0000 | 0.0000 |
| | LC4 3 | -25.3971 | -3.681e-03 | -46.7342 | 0.0000 | 0.0000 | 0.0000 |
| | LC3 4 | -6.322e-03 | -0.3507 | 143.3361 | 0.0000 | 0.0000 | 0.0000 |
| | LC5 5 | -3.914e-03 | -0.1325 | 27.1509 | 0.0000 | 0.0000 | 0.0000 |
| 96 | LC1 1 | -4.408e-06 | -0.1630 | 58.2946 | 0.0000 | 0.0000 | 0.0000 |
| | LC2 2 | -2.798e-05 | 0.0204 | 13.3637 | 0.0000 | 0.0000 | 0.0000 |
| | LC4 3 | 2.038e-05 | 1.953e-03 | 0.6998 | 0.0000 | 0.0000 | 0.0000 |
| | LC3 4 | -2.669e-06 | -0.3902 | -137.6105 | 0.0000 | 0.0000 | 0.0000 |
| | LC5 5 | -3.078e-03 | -0.0714 | -24.8876 | 0.0000 | 0.0000 | 0.0000 |

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3D ANALYSIS OF AN AIRCRAFT HANGER

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*** Support Reactions ***

| Node | Cas/Cmb | FX KPS | FY KPS | FZ KPS | MX FT-KPS | MY FT-KPS | MZ FT-KPS |
|---|---|---|---|---|---|---|---|
| 102 | LC1 1 | 2.107e-05 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | LC2 2 | 1.696e-04 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | LC4 3 | -1.337e-04 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | LC3 4 | 1.306e-05 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | LC5 5 | 0.0186 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 103 | LC1 1 | -7.909e-07 | -13.0090 | 22.9713 | 0.0000 | 0.0000 | 0.0000 |
| | LC2 2 | 3.339e-07 | -2.0411 | -9.2657 | 0.0000 | 0.0000 | 0.0000 |
| | LC4 3 | 1.848e-05 | -0.0781 | -0.6473 | 0.0000 | 0.0000 | 0.0000 |
| | LC3 4 | -1.490e-07 | 15.5096 | 129.7886 | 0.0000 | 0.0000 | 0.0000 |
| | LC5 5 | 1.023e-04 | 2.8032 | 23.7223 | 0.0000 | 0.0000 | 0.0000 |
| 109 | LC1 1 | 7.909e-07 | 13.0149 | 19.9003 | 0.0000 | 0.0000 | 0.0000 |
| | LC2 2 | -3.339e-07 | 1.9642 | 12.7933 | 0.0000 | 0.0000 | 0.0000 |
| | LC4 3 | -1.848e-05 | 0.0797 | -3.0838 | 0.0000 | 0.0000 | 0.0000 |
| | LC3 4 | 1.490e-07 | 18.6511 | -136.6190 | 0.0000 | 0.0000 | 0.0000 |
| | LC5 5 | -1.023e-04 | 3.6052 | -26.0774 | 0.0000 | 0.0000 | 0.0000 |
| 168 | LC1 1 | 0.0367 | 0.1321 | 47.1577 | 0.0000 | 0.0000 | 0.0000 |
| | LC2 2 | -2.874e-04 | 0.0218 | 7.4493 | 0.0000 | 0.0000 | 0.0000 |
| | LC4 3 | -0.1876 | -3.277e-05 | -0.0172 | 0.0000 | 0.0000 | 0.0000 |
| | LC3 4 | 1.350e-03 | -0.3515 | 144.2225 | 0.0000 | 0.0000 | 0.0000 |
| | LC5 5 | 4.386e-03 | -0.1389 | 28.5896 | 0.0000 | 0.0000 | 0.0000 |

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3D ANALYSIS OF AN AIRCRAFT HANGER

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*** Support Reactions ***

| Node | Cas/Cmb | FX KPS | FY KPS | FZ KPS | MX FT-KPS | MY FT-KPS | MZ FT-KPS |
|---|---|---|---|---|---|---|---|
| 173 | LC1 1 | 1.780e-05 | -0.1395 | 52.1495 | 0.0000 | 0.0000 | 0.0000 |
| | LC2 2 | -2.686e-05 | -0.0216 | 7.5115 | 0.0000 | 0.0000 | 0.0000 |
| | LC4 3 | 2.695e-05 | 5.627e-06 | 2.171e-03 | 0.0000 | 0.0000 | 0.0000 |
| | LC3 4 | -4.285e-08 | -0.3922 | -138.0671 | 0.0000 | 0.0000 | 0.0000 |
| | LC5 5 | 3.494e-03 | -0.0752 | -26.1706 | 0.0000 | 0.0000 | 0.0000 |
| 179 | LC1 1 | -7.882e-05 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | LC2 2 | 1.629e-04 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | LC4 3 | -2.128e-04 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | LC3 4 | 1.071e-06 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | LC5 5 | -0.0212 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 180 | LC1 1 | 1.090e-07 | -11.2873 | 20.1570 | 0.0000 | 0.0000 | 0.0000 |
| | LC2 2 | 3.188e-07 | -1.9937 | 1.7399 | 0.0000 | 0.0000 | 0.0000 |
| | LC4 3 | 3.879e-05 | -2.437e-04 | -1.880e-03 | 0.0000 | 0.0000 | 0.0000 |
| | LC3 4 | -5.425e-07 | 15.5232 | 130.2504 | 0.0000 | 0.0000 | 0.0000 |
| | LC5 5 | -1.094e-04 | 2.9413 | 24.9505 | 0.0000 | 0.0000 | 0.0000 |
| 186 | LC1 1 | -1.090e-07 | 11.2948 | 15.2025 | 0.0000 | 0.0000 | 0.0000 |
| | LC2 2 | -3.188e-07 | 1.9866 | 1.7934 | 0.0000 | 0.0000 | 0.0000 |
| | LC4 3 | -3.879e-05 | 5.901e-04 | -0.0217 | 0.0000 | 0.0000 | 0.0000 |
| | LC3 4 | 5.425e-07 | 18.6407 | -136.4043 | 0.0000 | 0.0000 | 0.0000 |
| | LC5 5 | 1.094e-04 | 3.7782 | -27.3452 | 0.0000 | 0.0000 | 0.0000 |

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HANGER

3D ANALYSIS OF AN AIRCRAFT HANGER

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*** Support Reactions ***

| Node | Cas/Cmb | FX KPS | FY KPS | FZ KPS | MX FT-KPS | MY FT-KPS | MZ FT-KPS |
|---|---|---|---|---|---|---|---|
| 214 | LC1 1 | -0.0106 | -3.469e-18 | 3.8682 | 0.0000 | 0.0000 | 0.0000 |
| | LC2 2 | 4.800e-05 | 0.0000 | -7.106e-03 | 0.0000 | 0.0000 | 0.0000 |
| | LC4 3 | -25.3348 | 2.168e-19 | 51.1078 | 0.0000 | 0.0000 | 0.0000 |
| | LC3 4 | -5.851e-04 | 0.0000 | 0.7287 | 0.0000 | 0.0000 | 0.0000 |
| | LC5 5 | -2.116e-04 | -3.469e-18 | 0.0743 | 0.0000 | 0.0000 | 0.0000 |

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HANGER
3D ANALYSIS OF AN AIRCRAFT HANGER

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*** Support Reactions ***

| Quantity | Limit | Value | Unit | Node | Ldcmb/Cs |
|---|---|---|---|---|---|
| FX | Max | 0.0367 | KPS | 168 | LC1 1 |
| | Min | -25.3971 | KPS | 89 | LC4 3 |
| FY | Max | 18.6511 | KPS | 109 | LC3 4 |
| | Min | -13.0090 | KPS | 103 | LC1 1 |
| FZ | Max | 144.2225 | KPS | 168 | LC3 4 |
| | Min | -138.0671 | KPS | 173 | LC3 4 |
| MX | Max | 0.0000 | FT-KPS | 1 | LC1 1 |
| | Min | 0.0000 | FT-KPS | 1 | LC1 1 |
| MY | Max | 0.0000 | FT-KPS | 1 | LC1 1 |
| | Min | 0.0000 | FT-KPS | 1 | LC1 1 |
| MZ | Max | 0.0000 | FT-KPS | 1 | LC1 1 |
| | Min | 0.0000 | FT-KPS | 1 | LC1 1 |